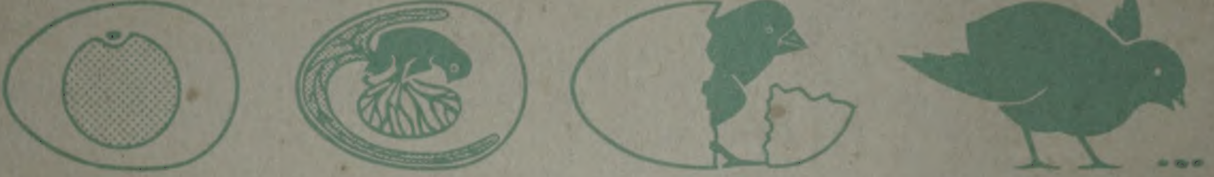
VISUAL SCIENCE FOURTH BOOK



Plants and Animals

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1 *FIRST BOOK*

Living things: how young animals begin life; where plants store food; life-cycles of plants and animals. Water: its role in nature; ice, water, steam; floating and sinking. Earth and sun: seasons, climates, day and night. Sound: how it is caused and how it travels; loud and soft sounds; high notes and low.

2 *SECOND BOOK*

Air: its weight and power; burning and breathing. Heat: its sources; how heat travels through air, through liquids, through solids; using and keeping heat. Light: how it travels; brightness and colour; reflection. Weight and work: falling and gliding; levers; arms and legs.

3 *SCIENCE IN THE HOME*

Water: how it comes to our homes; hard and soft water; water and rust. Food: the role of cooking; digestion and nutrition; why food must be kept clean. Glass: how it is made; its properties; its value in the home. Electricity: heating and lighting; the electric bell; the fuse.

4 *PLANTS AND ANIMALS*

The life-histories of plants and animals in mor detail; introduction to the chemistry of the soil how seeds form and germinate; the nitroge cycle; the carbon cycle; first lessons in anima and human physiology; further aspects of th behaviour of liquids; how water rises in plants introduction to study of weather.

5 *MOVING ABOUT*

Devices which assist movement: the wheel, th screw, the propeller, the jet, the oar. Stopping starting and turning (acceleration and inertia) Movement of animals in water, in the air, or land, underground; limbs, muscles, nerves Pressure in air and in liquids. The magnet.

6 *MACHINES WHICH WORK FOR MAN*

The sun as a source of power: from coal to steam and steam engines, to the turbine and electricity, to coal gas; watermills and windmills. Simple chemical changes as sources of power. Electrolysis and electro-magnetism. Gravity and work. Sources of power compared.

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BANGALORE-4, (INDIA)

PRINTED IN GREAT BRITAIN BY D. R. HILLMAN & SONS LTD., FROME, SOMERSET

PLANTS AND ANIMALS

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6, SHRI B. P. WADIA ROAD,
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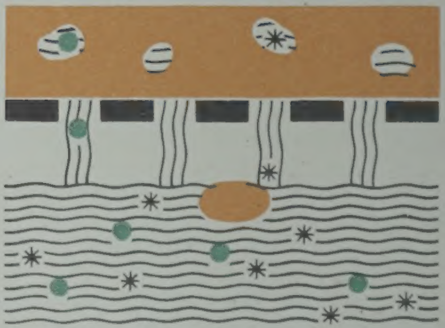

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SOLE DISTRIBUTORS: GEORGE G. HARRAP & CO LTD 182 HIGH HOLBORN LONDON WC1 . SYDNEY . WELLINGTON

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HOW TO USE THIS BOOK

Science is a way of learning by observing facts, noting the connections between them, and testing the knowledge we gain by careful experiment. The purpose of this book is to help you to study some of the wonders of plant and animal life in a scientific way.

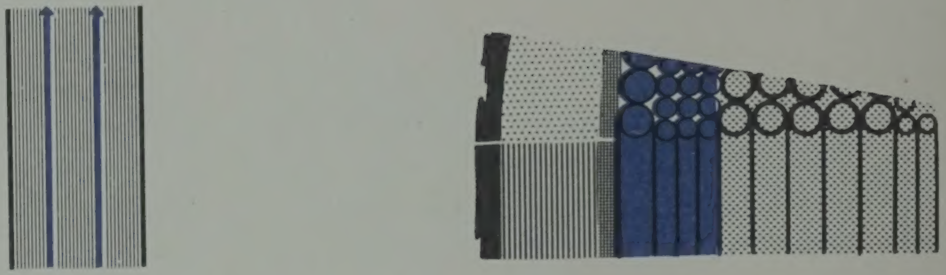
The pictures are not intended to show you how things look, like photographs. *They are made especially to give you information,* like a map or an architect's drawing. Every line and every colour has something to tell you. On page 18, for instance, you will see that *black* is used to show carbon and *orange* to show oxygen. When we next speak of carbon and oxygen, on page 22, the same colours are used to show them. Certain simple drawings, called "Isotype symbols", are used again and again, always with the same meaning, so that you can recognise and understand them easily every time you see them.

It would be a mistake to think that because this book contains many pictures and few words it can be read and understood very quickly. Isotype pictures are packed with information, and the longer and more carefully you study them the more you will learn from them. (Try to answer some of the questions we have asked, and you may not be able to do so after only a quick glance at the pictures, but you *will* be able to after you have examined them thoroughly.)

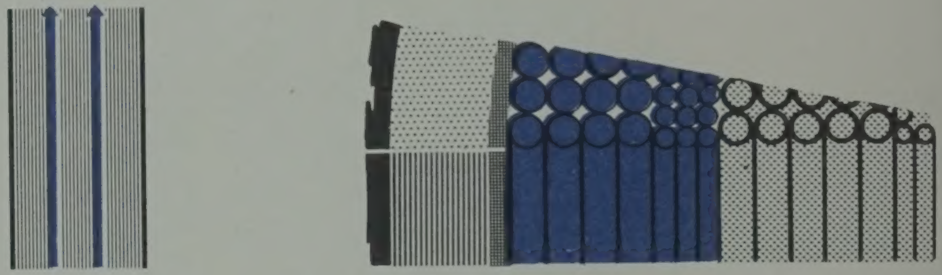
We hope that you will enjoy studying this book, and that it will make you want to read many other books about the science of plants and animals. You will find a useful book list on page 49. But science can never be learnt from books alone. You will learn much more about plants by cultivating a patch of garden yourself and finding out when various seeds must be sown, when different plants begin to flower, what kind of soil suits different plants. You will learn more about animals by keeping your own pets, or by helping to feed and care for farm animals. You can also add to your knowledge by doing experiments like those we have suggested on pages 17, 29, 41 and 48. When you have done that, turn again to this book and you will find that it helps to make your knowledge more useful and orderly by showing you how the results of your observations and experiments can all be fitted together into a pattern you can understand.

The Editors

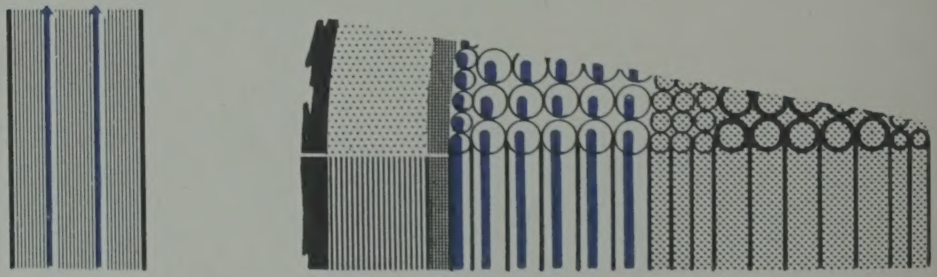
A Year in the Life of a Tree



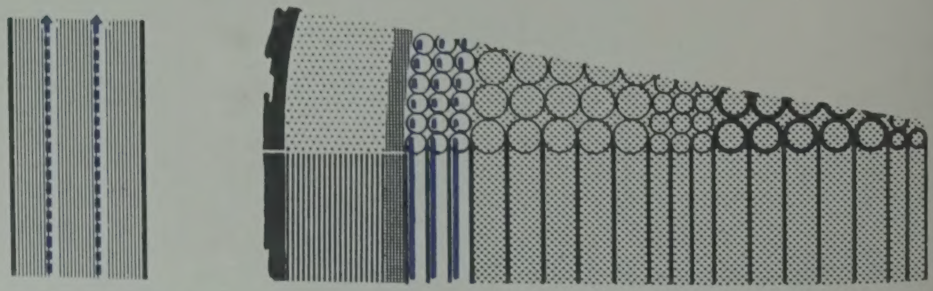
Spring: Leaf buds open and moisture begins to rise.



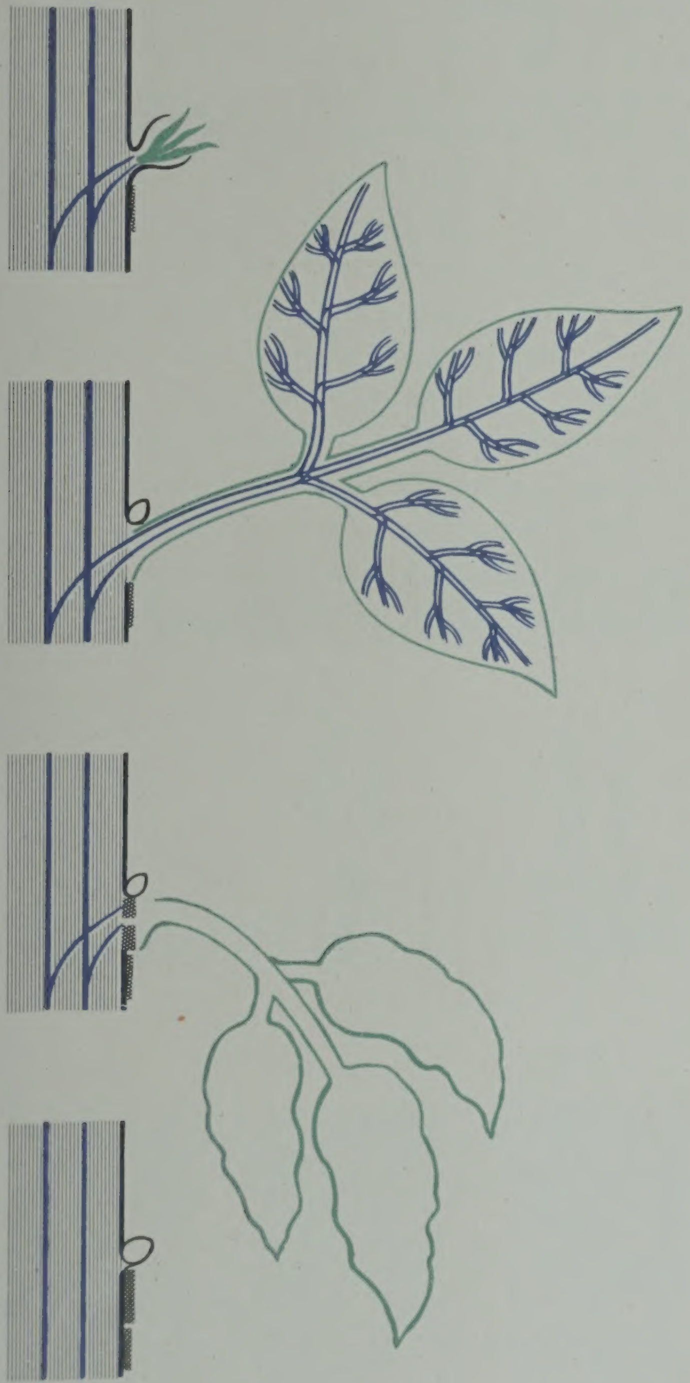
Summer: The tree is in full leaf; more water rises.



Autumn: Leaves fall; the flow of moisture weakens.



Winter: Boughs are bare; the wood is almost dry.



Look first at the pictures on page 6. Blue stands for water, orange for the sun's heat.

1 Which part of the tree takes in water? Which part gives off water-vapour?

2 The tree loses more moisture in summer than winter partly because the weather is warmer. Can you think of another reason?

3 The second column of pictures shows the amount of water rising inside the tree. What connection do you notice between the amount of moisture the tree loses and the amount of water which rises?

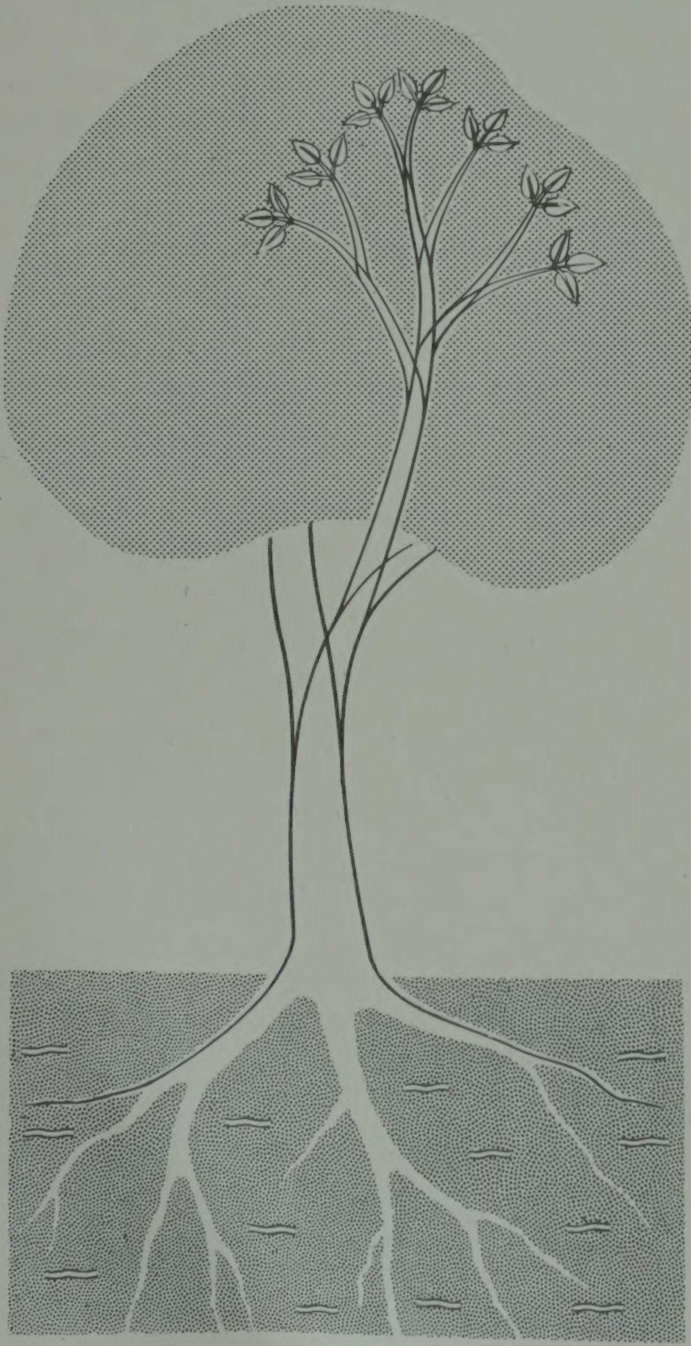
4 The third column shows what happens inside the trunk of a tree. Which tubes carry more water, those near the bark or those near the centre of the trunk? What do you notice about those near the centre?

5 Throughout the year new tubes are growing up around the old ones. In spring and summer most of the new tubes are slightly thicker. Is this true in autumn and winter?

6 How does water get from the trunk of the tree to the leaf-bud? To the tip of the full-grown leaf? *(See pictures on this page.)*

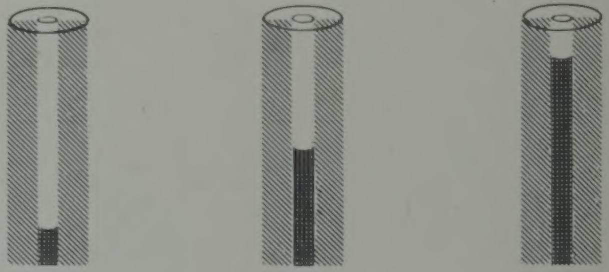
7 In autumn a cork-like tissue forms round the stem of the leaf. How does this prevent moisture escaping when the leaves break off and fall?

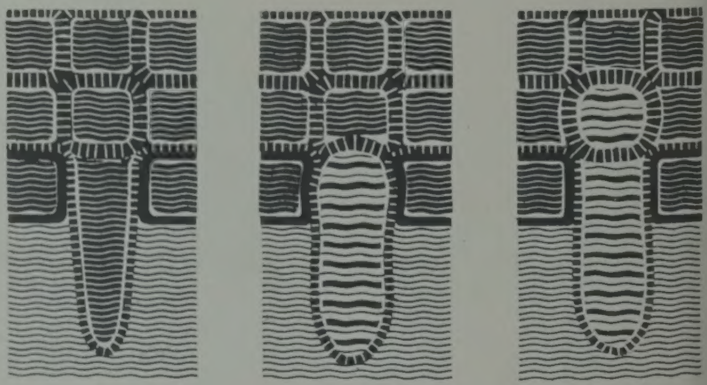
How Water Climbs from Soil to Tree-top

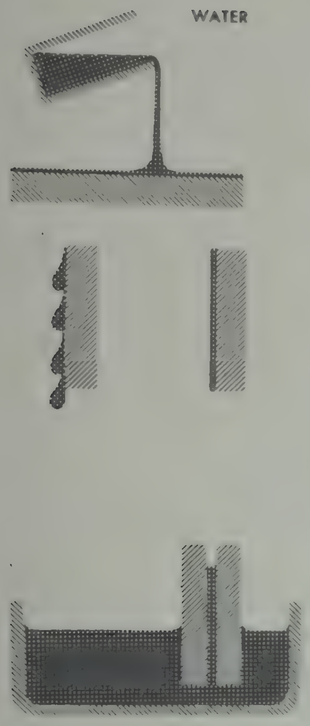


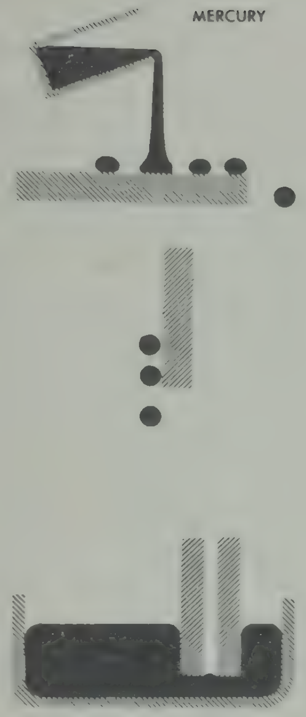
How does water climb from the soil to the topmost leaves of a tree? The tree takes in water through the root-hairs which grow from the large, branching roots. Each hair is made up of a gluey liquid called *protoplasm*, surrounded by a thin outer skin. Water from the soil can soak through this skin into the root, but the larger particles in the protoplasm cannot pass through the skin into the soil. More and more water collects in the root-hairs and pushes its way upwards.

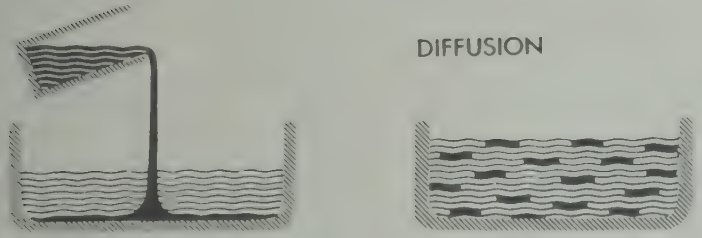
The narrow tubes inside the trunk and branches are able to draw water upwards. The first few pictures on page 9 will help you to understand this. The rising of the water is due, in part, to this *capillary attraction.*

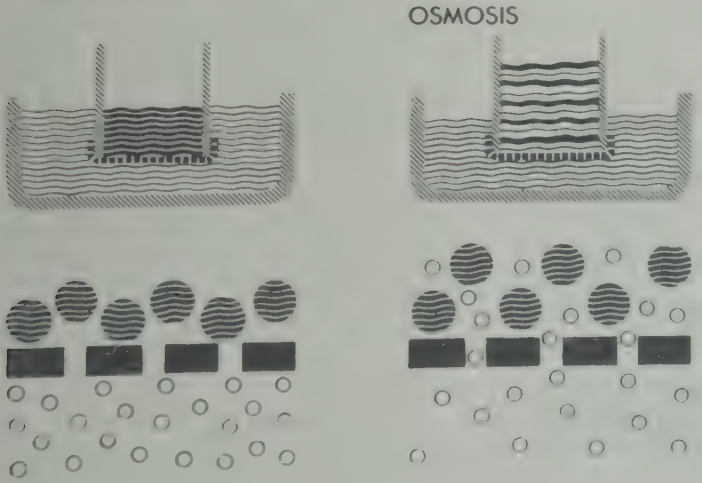












Water will spread out and wet a table-top. Mercury will form globules which glide over the surface without wetting it.

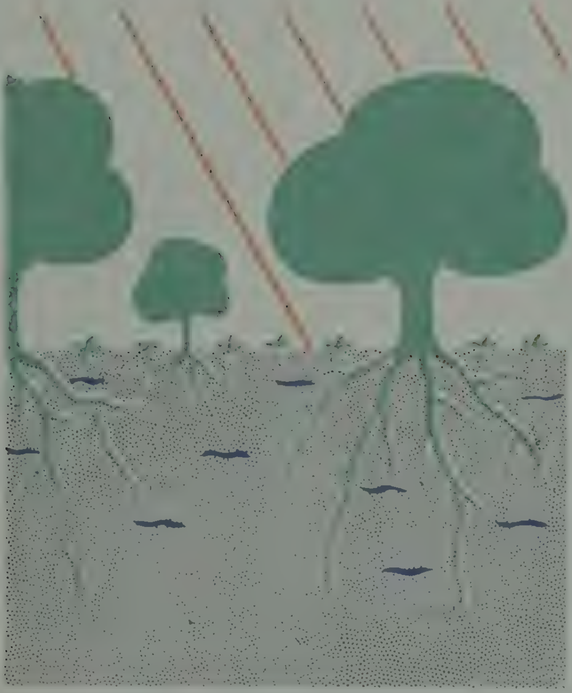
Raindrops trickle slowly down window panes, clinging to the glass. Drops of mercury would run down swiftly, leaving no trace on the glass. Water is strongly attracted by a wood or glass surface; but one particle of mercury is more strongly attracted by another than it is by either wood or glass.

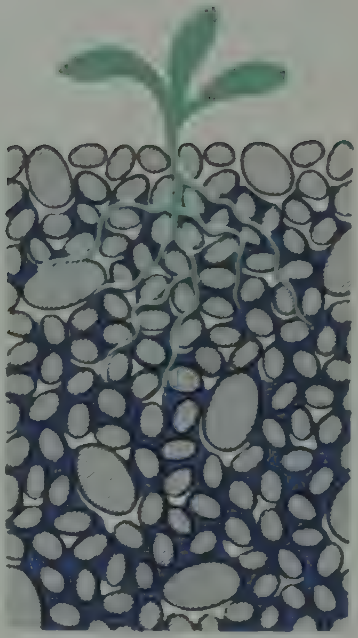
The surface of water in a glass bowl curves upwards slightly at the edge; mercury curves downwards slightly. In a narrow glass tube, a small volume of water touches rather a large surface of glass. The surface of the glass has a powerful attraction for the water and draws it above the level in the bowl. Mercury in a narrow tube stays below that level.

Pour some coloured syrup into a glass of water. At first it will sink to the bottom, because it is heavier, bulk for bulk, than the water, but in time it will mix thoroughly with the water. This thorough mixing of two different fluids is called *diffusion.*

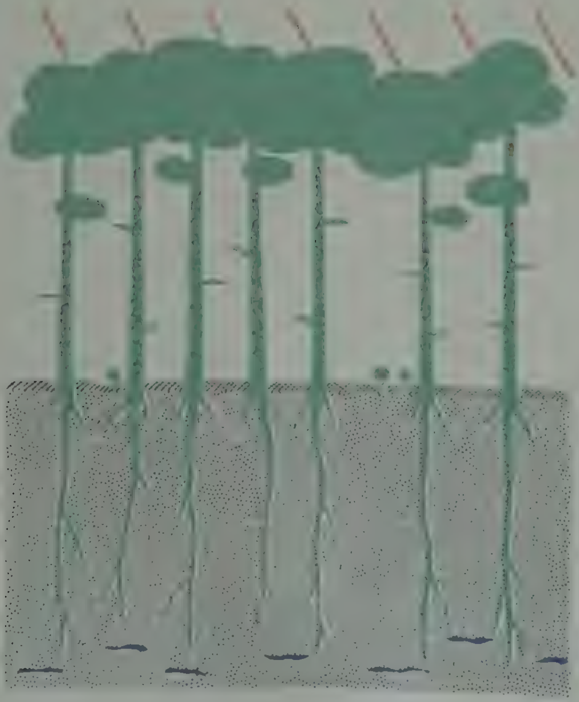
Now take a glass tube and seal the bottom with a skin of Cellophane. Pour some coloured syrup into the tube, and hang it in a glass of water. After a day or two you will notice that water has entered the tube and mixed with the syrup, but no syrup has left the tube to mix with the water. The tiny particles of water can pass through the pores of the Cellophane; the larger particles of syrup cannot. The rising of water in roots depends on this sort of one-way movement, which is called *osmosis.*

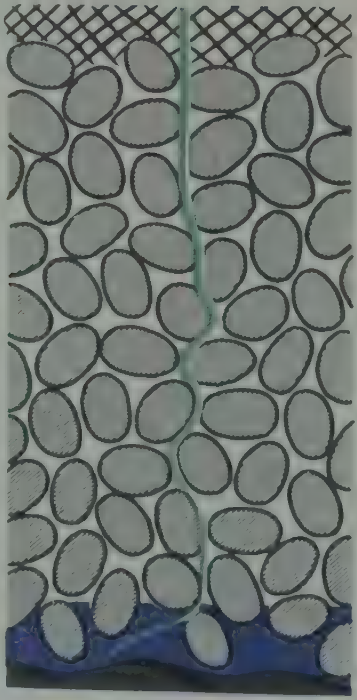
Different Kinds of Soil



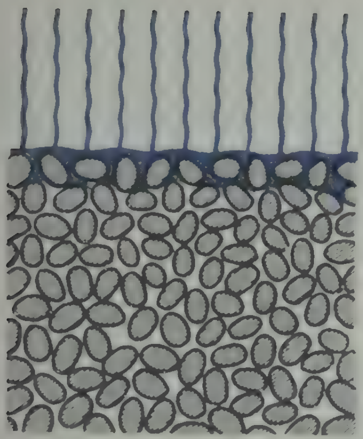


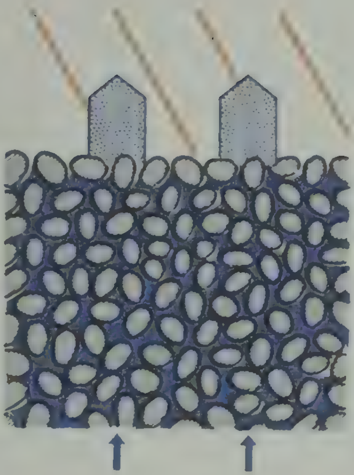
In this wood the deep roots of oak trees, medium roots of shrubs and the shallow roots of the wild flowers all find the moisture they need. If you examined some of the loamy soil through a microscope you would find it contained many tiny particles of clay, covered with a film of water, and fewer and larger particles of sand with air-spaces between them.

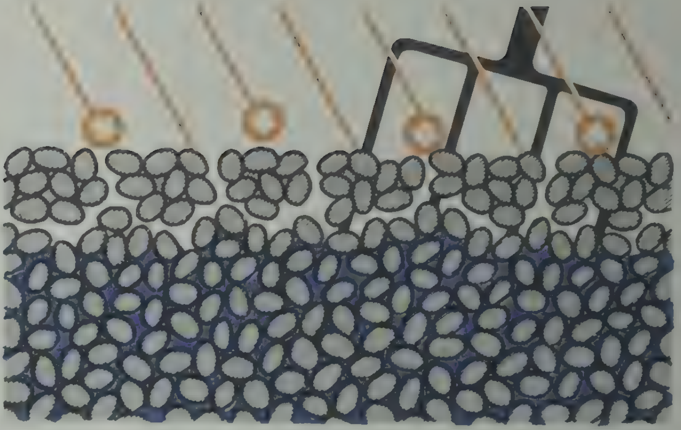


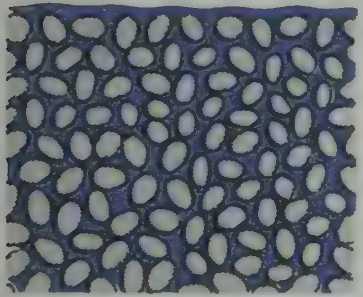


The pine trees in this wood grow so close together that hardly any sunshine reaches the ground below them. Their roots have to go deep down into the soil to find water. Little grows between them except a few ferns and toadstools. The top-soil is composed mainly of large sand particles. When it rains the water trickles down between these particles until it reaches the hard soil beneath.

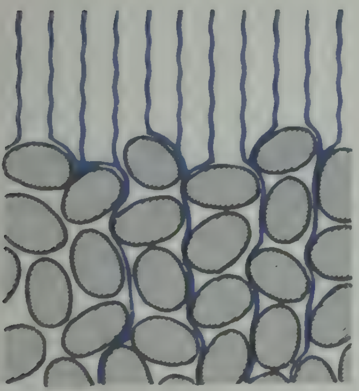


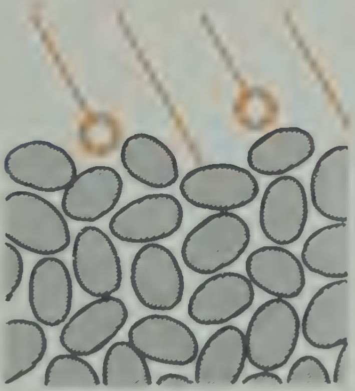


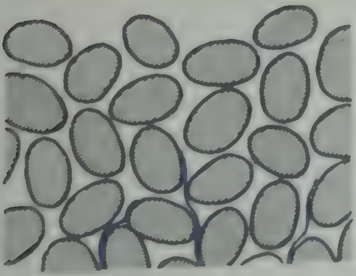




This soil is made up of small particles of clay.







This soil is made up of larger particles of sand.

1 Through which kind of soil does water penetrate more quickly, clay soil or sandy soil? In which kind does the top layer keep moist longer?

2 In warm weather which kind of soil loses more water-vapour to the surrounding air? Which kind of soil becomes warmer?

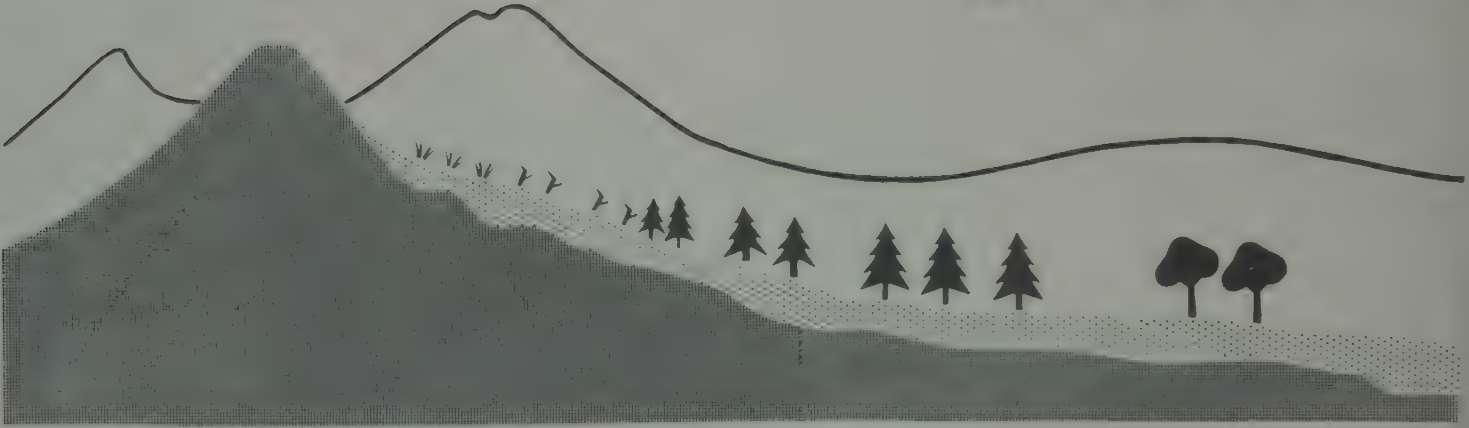
3 Suggest a reason why soil from which water is evaporating keeps cool while soil where there is no evaporation gets warm.

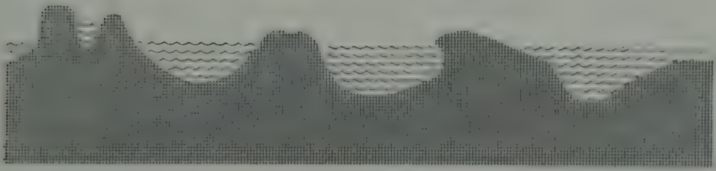
4 How does water rise through clay soil? Is this similar to the way in which moisture rises in the trunk of a tree? Why will water not rise through sandy soil?

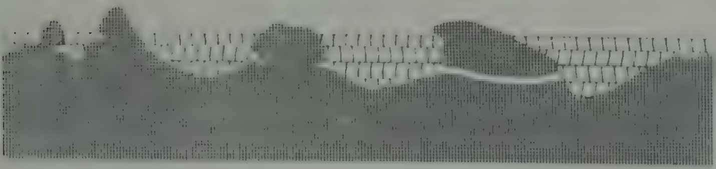
5 Why is there less evaporation from clay soil after it is raked? Why does it become warmer?

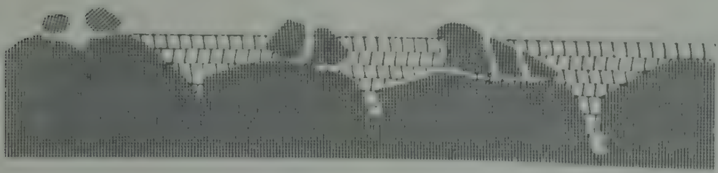
6 Before seedlings are planted in clay soil should the soil be raked or not?

How Soil is Formed

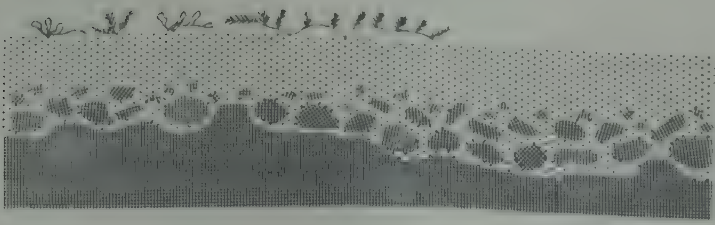


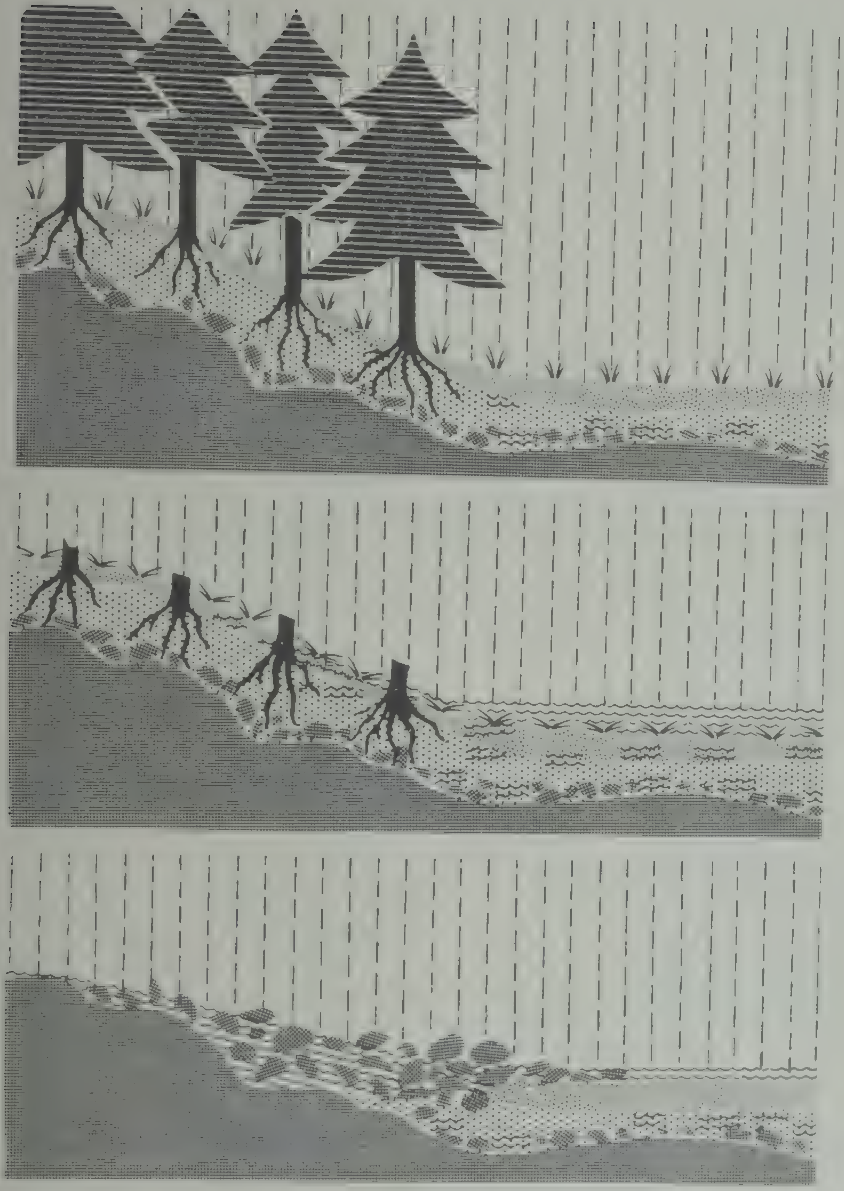






After rain, puddles form in the rocky hollows of a hillside. A sharp frost comes, and as the water turns to ice it expands and cracks pieces from the rock. Year after year more puddles form and freeze until at last the surface of the rock is broken into many thousands of tiny soil particles. At first only lichen and moss will grow in the new and poor soil. Slowly, as these small plants die, the soil crumbles and mixes with the decayed plant-stuff. In time larger plants and trees can grow there.





How Soil is Lost

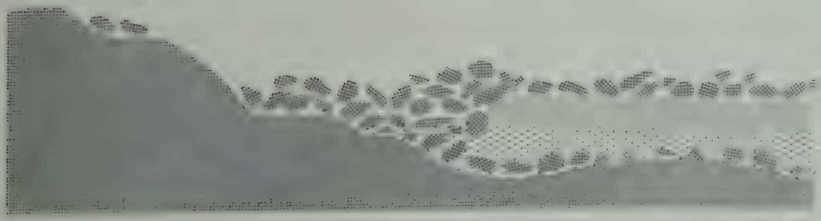
Soil is not always formed by the action of ice. In tropical countries rocks may gradually be broken into smaller and smaller particles by the intense heat of the sun; sometimes, too, chemical changes may very slowly break down rocks into fine soil.

Yet good, fertile soil can be lost or ruined in a few years if it is used without proper care and knowledge.

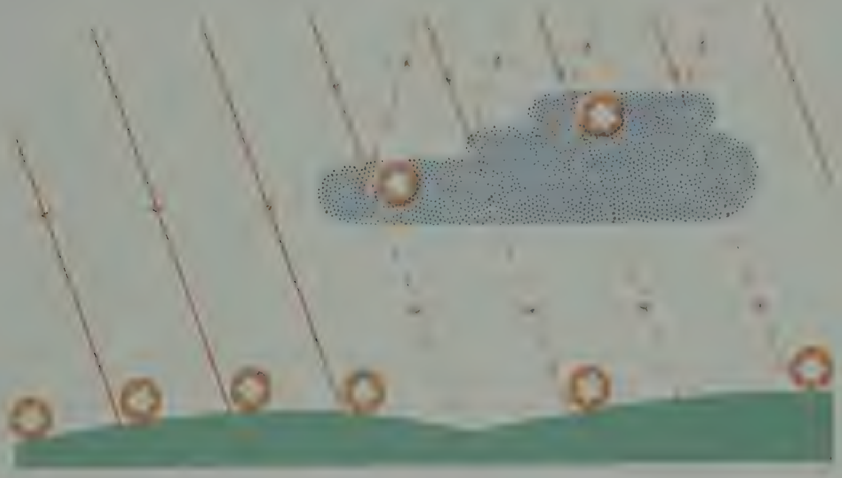
A pinewood grows on the layer of light, sandy soil covering this hillside. When there is heavy rain much of the water rises up the trees to take the place of the moisture which is always being lost from the foliage by evaporation. The tangle of roots helps to bind the soil together and to prevent the water washing it away down the hill.

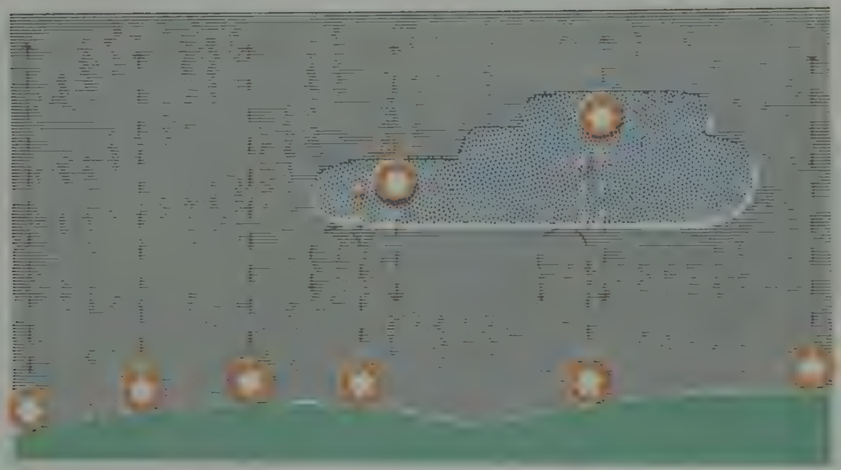
Then a large number of trees are felled and no young saplings are planted to replace them. When the next heavy rainstorm comes water goes gushing down the hillside, carrying soil with it, and flooding the plain below.

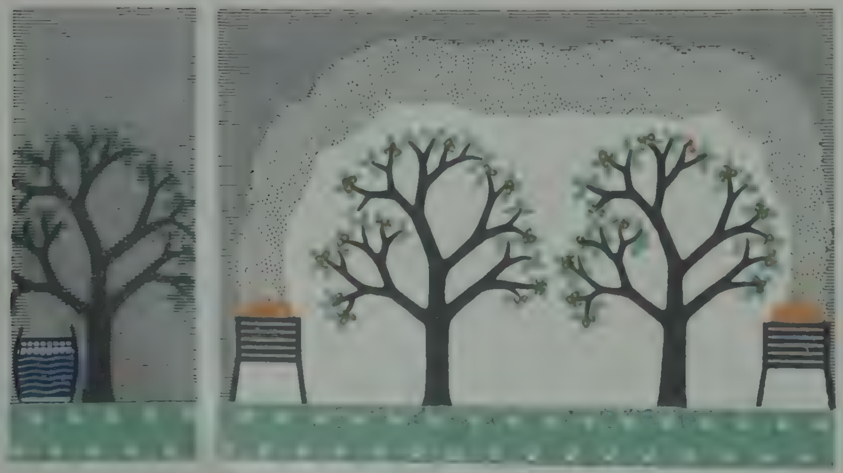
When the stumps are gone there is nothing at all to bind the soil together. Each storm of rain will wash more and more soil down the hillside until at last only the bare rock remains. At the foot of the hill the soil will be strewn with stones which have been swept down by the racing waters.



How Growing Things are Protected from the Cold







1 Look at the top picture on the left. Are all parts of the ground equally warm?

2 Does any of the sun's heat pass through cloud? What happens to the rest?

3 During the night does the earth receive more heat than it loses? Does the earth lose heat more rapidly where the sky is clear or where it is cloudy?

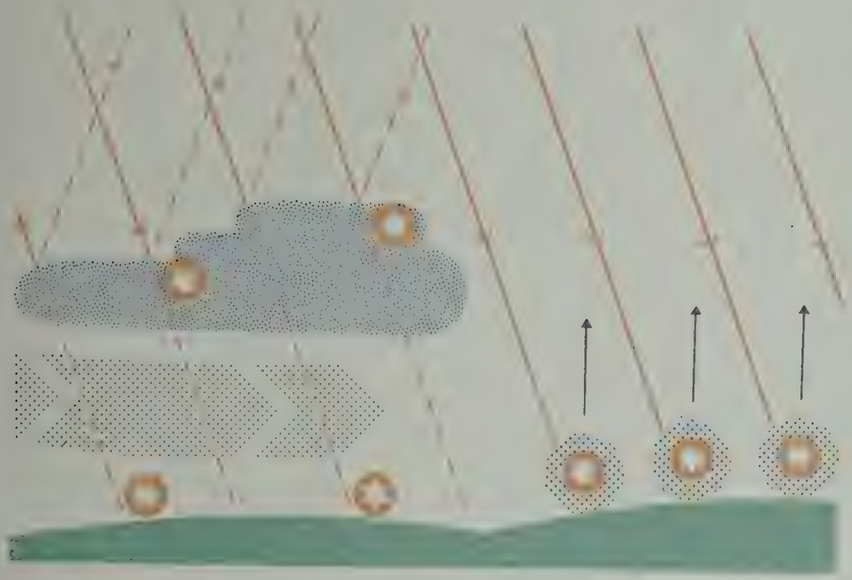
4 What happens to the heat which is radiated from the earth to a cloud during the night?

5 Does a cloud itself radiate heat during the night?

6 Look carefully at the bottom picture. Which season of the year is shown? Is it a warm night or a cold one?

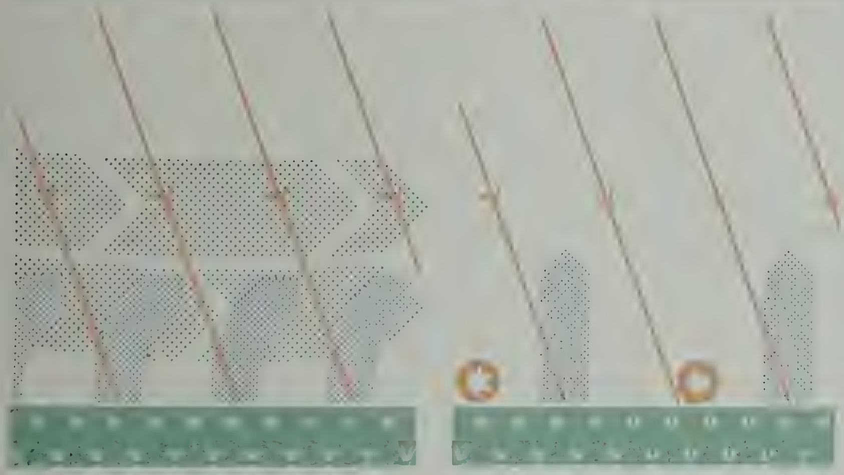
7 What will be the effect on the fruit crop if frost spoils the blossom?

8 When fires are lit near the trees the smoke forms a cloud over them. How does this cloud keep the trees warm?



9 During the daytime does the air near the ground become warmer where the sky is clear or where it is cloudy? What happens to air when it becomes warm?

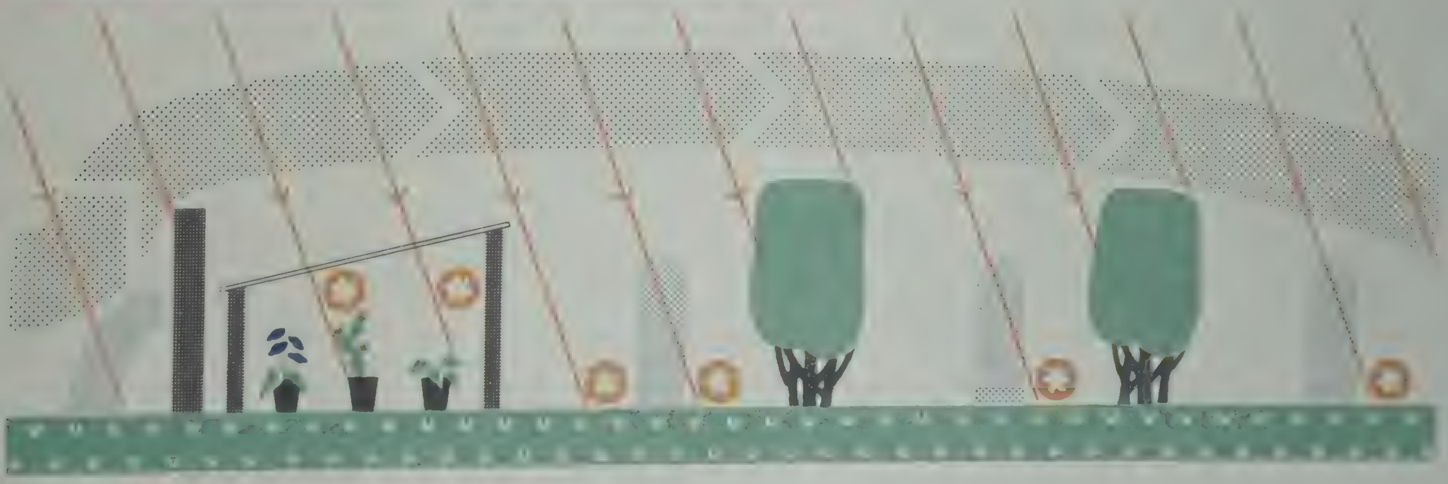
10 A gust of air moves in to replace the air that rises. Is this gust of air warmer or colder than the air it replaces?



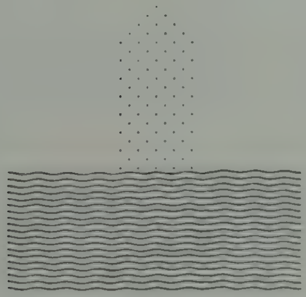
11 Now look at the next two pictures. Where does more evaporation take place, where the air is still or where a wind is blowing?

12 Would you expect the air to be colder where there is little evaporation or where there is much?

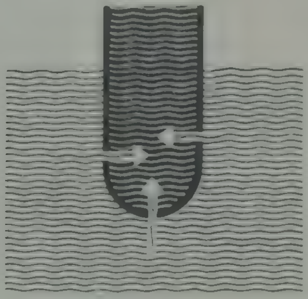
13 How do trees and greenhouses help to keep growing plants warm?



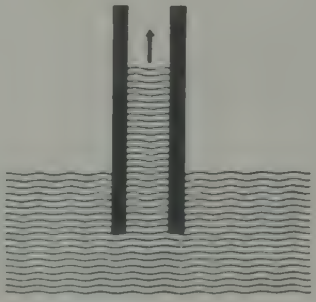
What We Have Learned about Plants and Water



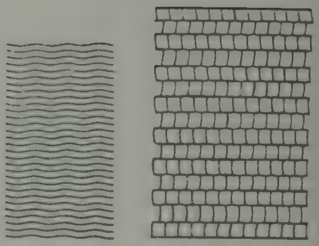
Evaporation



Osmosis



Capillarity



Freezing water expands

1. Water from the soil enters the roots of a tree and travels right up to the leaves. It is drawn up by many narrow tubes which lead through the trunk, branches, twigs and leaf-stems. It evaporates from the leaves and passes into the air in the form of water-vapour.

2. The root-hairs of a tree are covered with a thin skin. This skin will allow water to pass from the soil into the root, but it will not allow the thick fluid called protoplasm to pass from the root into the soil. This process is called osmosis. More and more water collects inside the root and pushes its way upwards.

When water is placed in a wooden or glass vessel, the surface of the wood or glass attracts the water which touches it. In a very narrow tube a small amount of water has a large surface touching the sides of the pipe, and the attraction is so strong that the water is sucked up the pipe. This process is called capillary attraction, and helps to explain how water is drawn upwards in the thin tubes inside a tree.

3. If you look at sandy soil you will see it is made up of particles, loosely touching one another. Clay soil is made up of much smaller particles which cling tightly together.

Water trickles quickly down through sandy soil. Scarcely any moisture remains near the top so there is little evaporation; in warm weather the surface becomes hot. In clay soil water soaks down slowly and gradually, and it can rise to the surface again by capillary attraction. In warm weather some of the sun's heat is used up in turning the water near the surface into water-vapour, and the soil is cool.

4. When water collects in the hollows of a rock and then freezes, it expands and cracks pieces from the rock. In the course of many years the rock may be broken into millions of tiny soil particles. Rock can also be broken down into soil particles by intense heat from the sun or by chemical changes. But, however it happens, the formation of soil always takes a great many years.

But soil can be lost or ruined in a few years by careless treatment. If a large number of trees are rooted up from a hillside covered with a thin layer of soil, there will be nothing left to bind the loose soil together and no decayed vegetable matter to soak up the water.

Each heavy rainstorm will wash more and more of the soil down the hillside.

5. During the day the sun radiates heat to the earth, but if there are clouds in the sky not all this heat will reach the ground. Some will be reflected back from the top layer of the cloud, and some will be used up in warming the cloud itself.

During the night the earth radiates heat and becomes cooler. If there are clouds in the sky they will slow down this loss of heat; they will reflect some of it back towards the earth and will also radiate some of their own warmth towards the ground. On cold spring nights farmers sometimes protect blossom from frost by lighting fires which cause artificial clouds of smoke to form above the trees.

When the sun's heat warms the air near the ground, that air expands, becomes lighter, and rises. Colder air moves in, in the form of a breeze or wind, to take its place. Many growing crops need to be kept warm. The farmer protects them from cold winds by means of hedges or screens of tall trees.

THINGS TO DO

1. Place a lump of sugar in a saucer and on it a little granulated sugar. Pour some red ink into the saucer and watch what happens. Try to explain it.

2. Take a freshly-cut marguerite or white carnation with a long stem and place it in a glass of water to which you have added a few drops of red ink. Look at the flower on each of the next three mornings. Note carefully what changes take place and explain them.

3. Cut crosswise through the stem of a wallflower or sunflower with a disused safety-razor blade. Examine the section through a good pocket lens. Try to pick out the tubes which draw up water. Make a large-scale drawing to show how these tubes are arranged inside the stem.

4. Place a leaf between two sheets of blotting paper and press it under a heavy book.

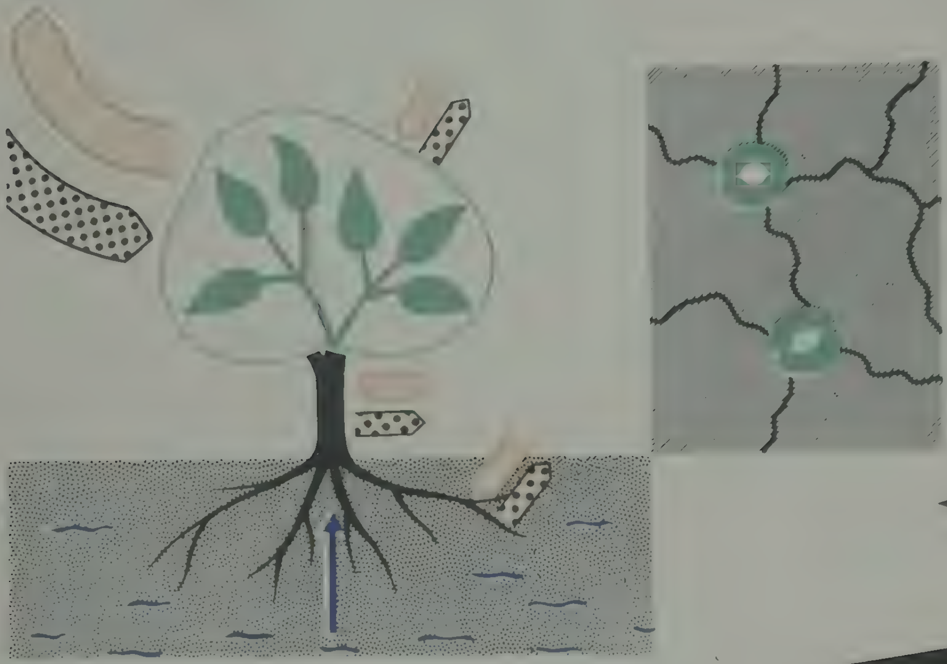
When the leaf is quite dry and brown, place it on a flat board and tap it gently all over with a stencil brush. After a time you will find that all the fleshy part of the leaf crumbles away. All that remains is the network of veins which carried water to all parts of the leaf.

5. Grease the rim of a glass tumbler and fill it to the brim with water. Now gently add more water until the level is well above the brim. How do you explain the fact that the water does not pour out over the edge?

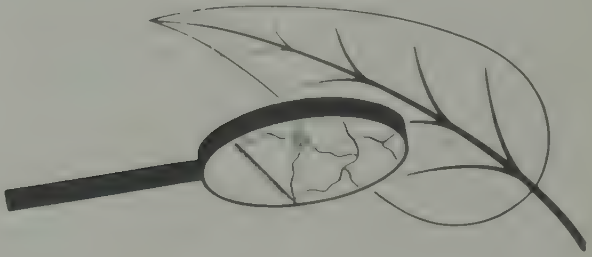
6. Make a list of things you have seen cracked or broken by water turning into ice. Make a second list of things you have seen cracked or broken by intense heat.

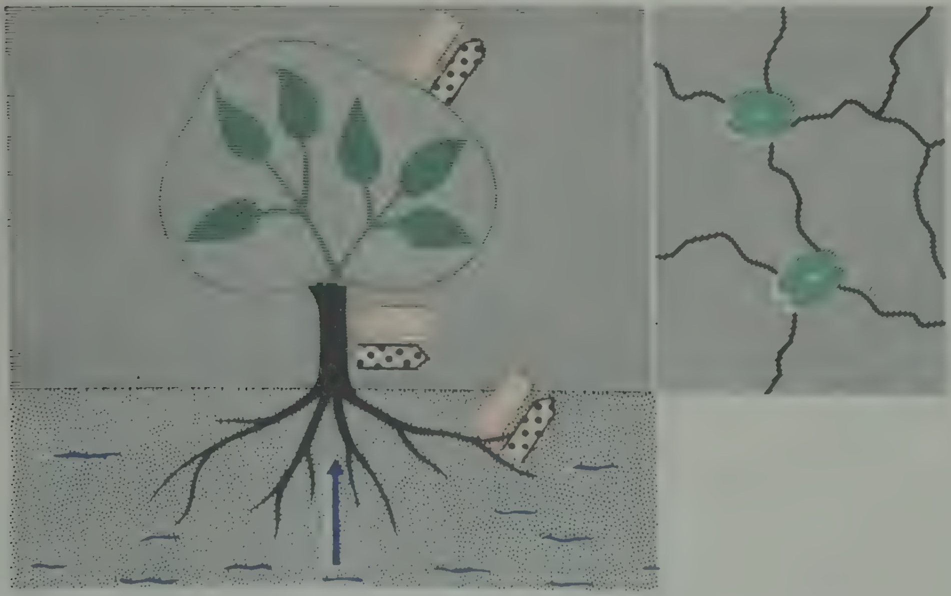
7. Float a few matches in a basin of water, with their heads near to one another. Touch the space in between with a piece of soap. What happens? Try to explain this.

How a Plant Makes its Own Food



During the day all parts of the plant—roots, stem and leaves—breathe in small quantities of oxygen and breathe out small quantities of carbon dioxide. But the leaves also take in much larger quantities of carbon dioxide, which they use to help make food for the plant, and give off larger quantities of oxygen.

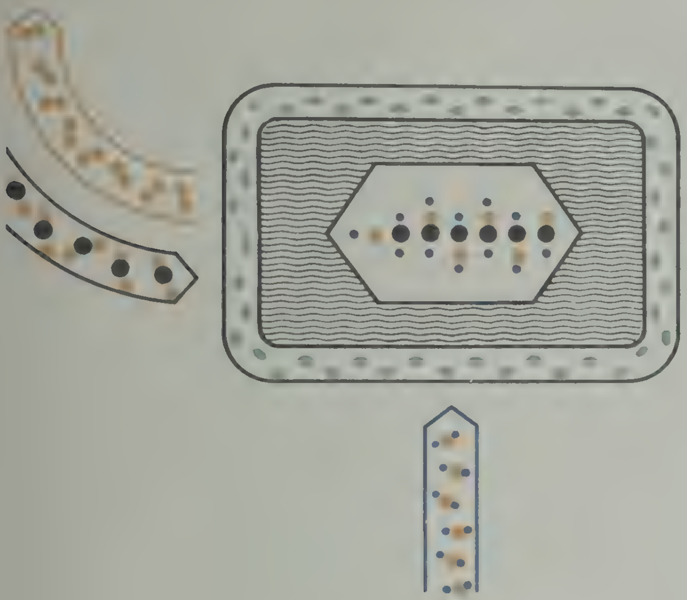


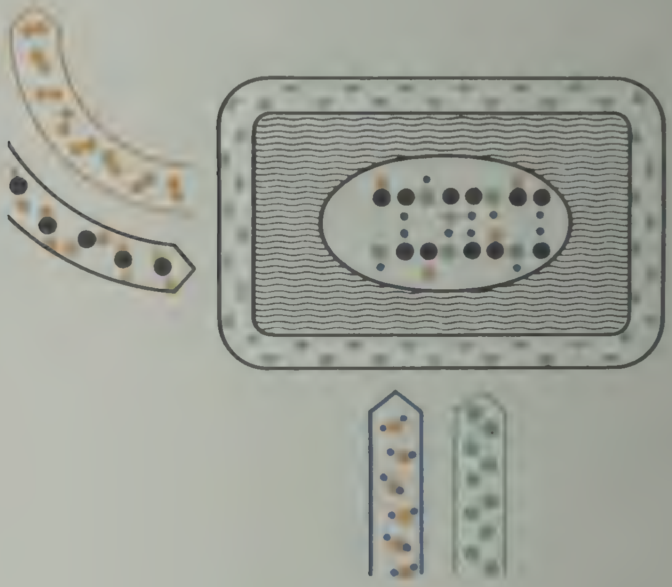


At night all parts of the plant go on breathing in a little oxygen and breathing out a little carbon dioxide. But the leaves no longer take in carbon dioxide and give out oxygen. If you examine the lower surface of a leaf through a powerful pocket lens, you will see a number of tiny pores. These pores are open during the day but closed at night.

Orange dots stand for oxygen.
Black dots stand for carbon.

Green dots stand for nitrogen and chlorophyll.
Blue dots stand for hydrogen.





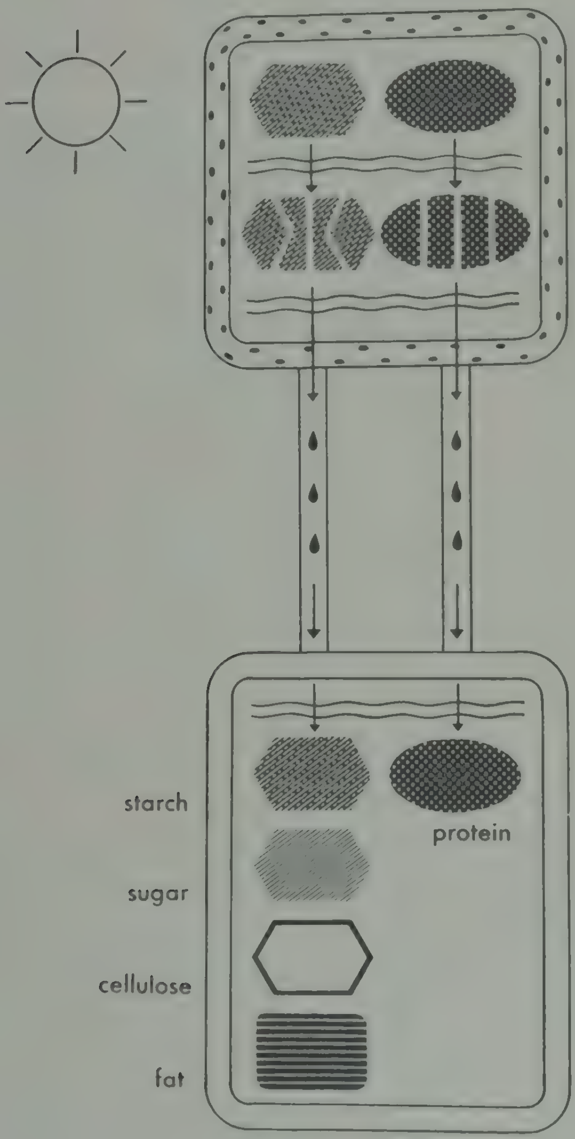
Many of the cells inside a leaf contain a green substance called chlorophyll. During the hours of daylight chlorophyll brings about important chemical changes in the other substances which enter the leaf.

Look at the first square diagram above. Water, which is made up of hydrogen and oxygen, enters the leaf through the stem. Carbon dioxide, which is made up of carbon and oxygen, comes in through the pores. Inside the leaf, carbon from the carbon dioxide combines with the hydrogen and oxygen from the water to form substances called *carbohydrates* which serve as food for the plant. Since this change takes carbon from the carbon dioxide, free oxygen is left which passes out through the pores of the leaf into the air, helping to keep it " fresh ".

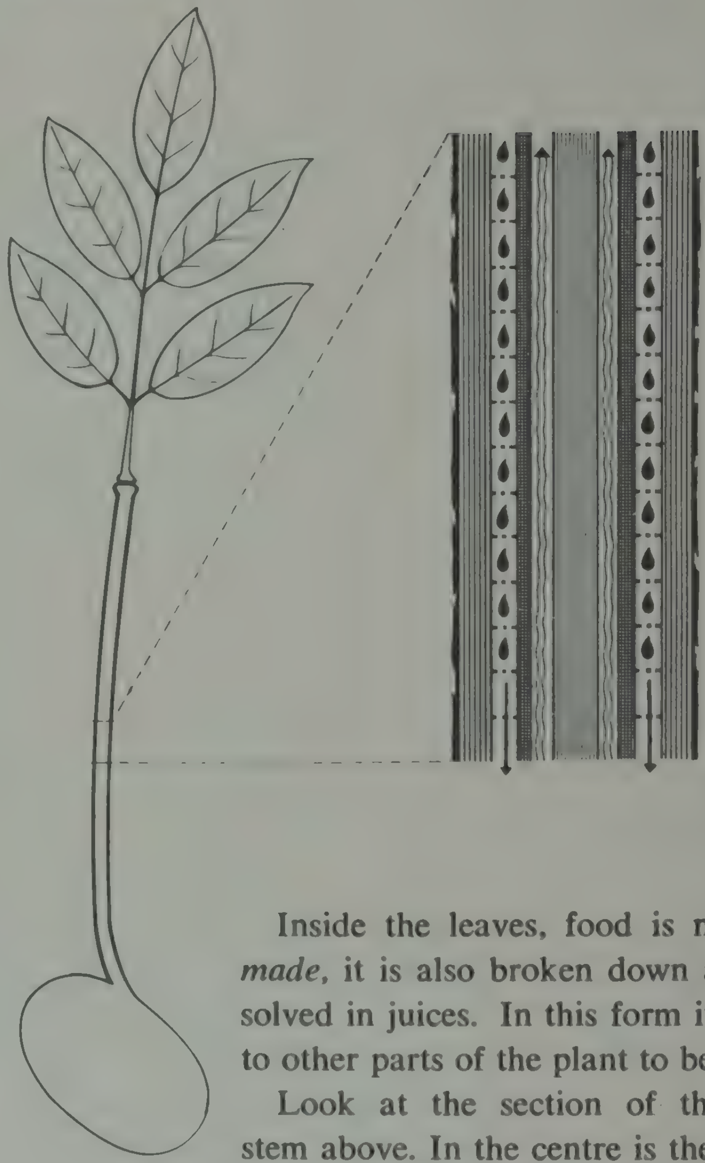
Now look at the second square picture. This time *nitrogen* from the soil comes into the leaf with the water. Inside the leaf, carbon, *nitrogen*, hydrogen and oxygen join together to form a food substance called protein. Again, free oxygen passes into the air.

These chemical changes which go on inside the leaf could not take place without chlorophyll and sunshine. You cannot, for instance, make carbohydrates and oxygen by mixing water and carbon dioxide together in a glass jar. Some of the carbon dioxide would dissolve in the water and make it slightly acid but there would be no other change.

Using the Food the Leaves Make

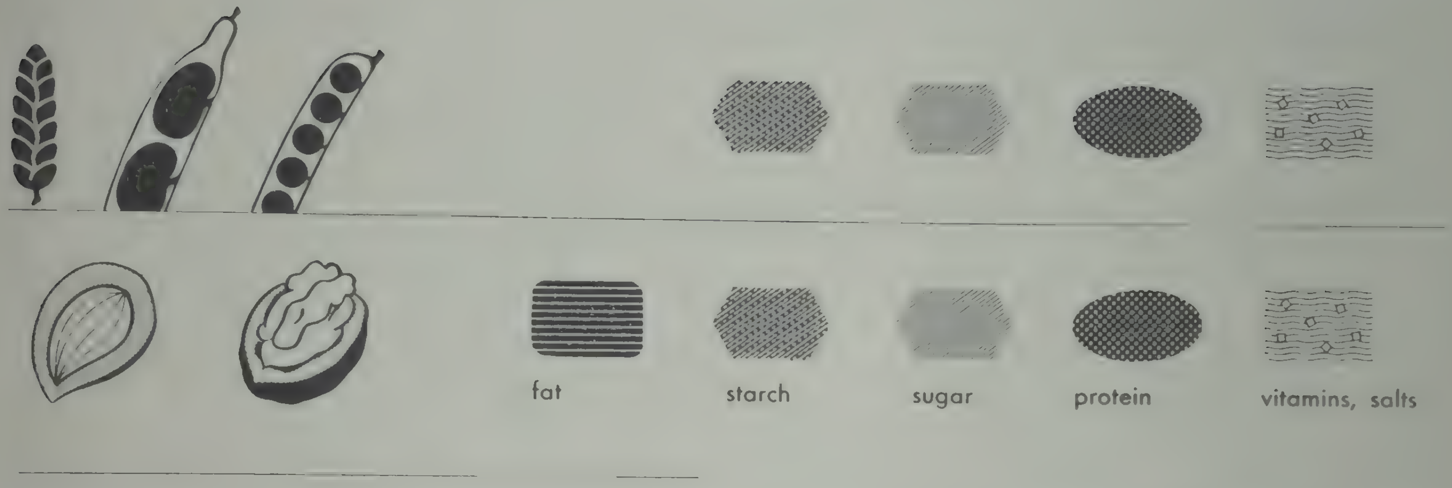


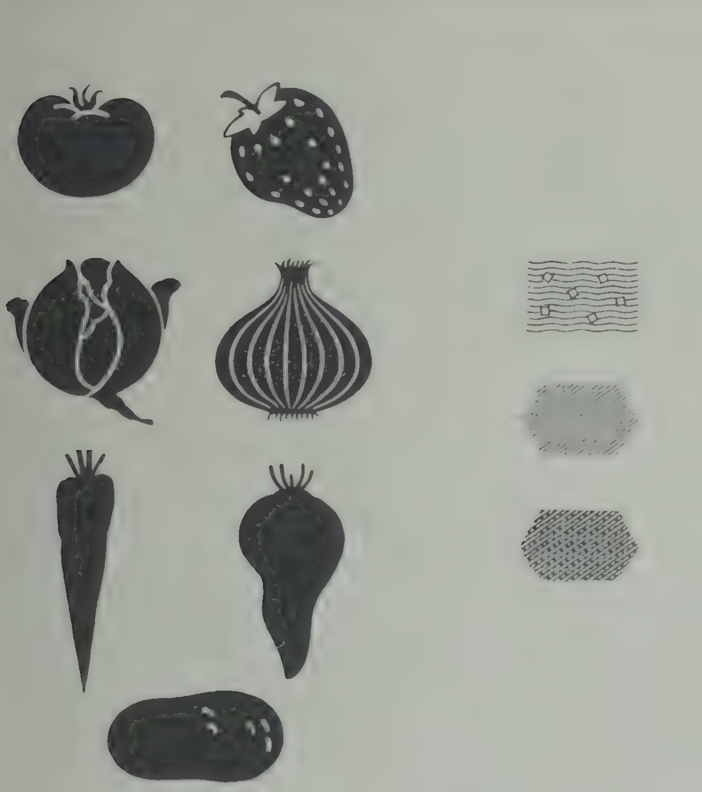
The food made in the leaves is stored in various parts of the plant. Besides the carbohydrates, which include starch, sugar and cellulose, there are also fats and proteins.

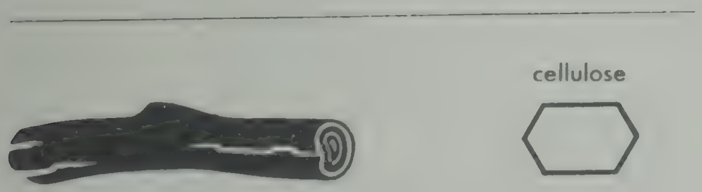


Inside the leaves, food is not only *made*, it is also broken down and dissolved in juices. In this form it travels to other parts of the plant to be stored.

Look at the section of the plant stem above. In the centre is the woody part containing the narrow tubes which draw up water. Between this and the outer skin is a fibre-like layer called *bast*. It contains a number of tubes made up of porous cells. The dissolved food can filter down through these tubes and reach all parts of the plant.







1 Which of the growing things shown on this page store food in their seeds? In their roots? In their leaves?

2 Which of them contain some kind of carbohydrate? Do they all contain protein? Which contain fat?

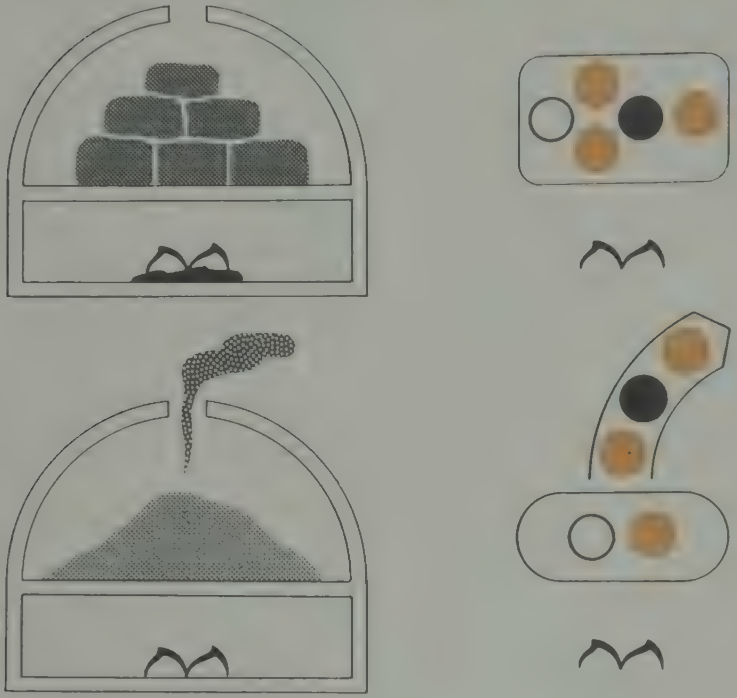
3 Can you name any nuts from which oil is often made?

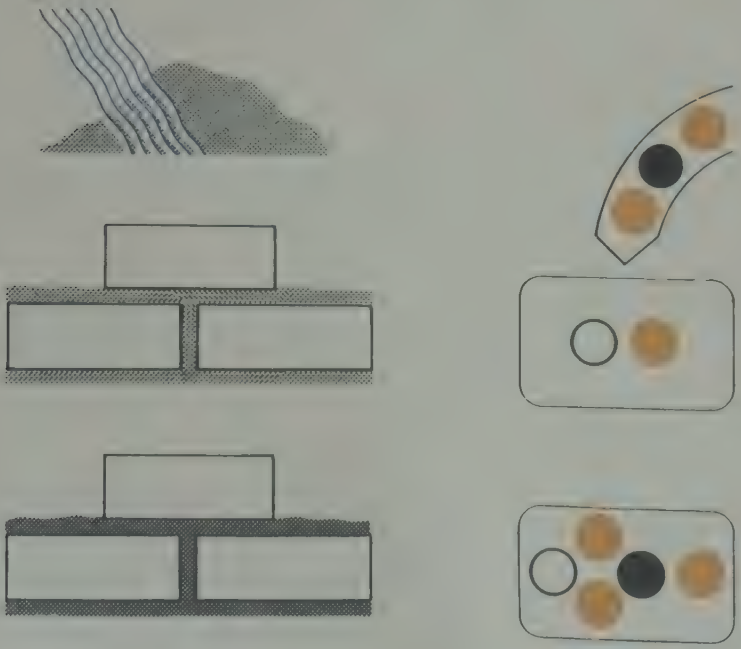
4 If you plant a grain of wheat (or a pea, or a bean) in the earth, how do you think the foodstuff in it will be used?

5 Which kind of carbohydrate do you think is important in a strawberry? In a potato? In wood?

6 Most plants contain salts made from substances found in the earth. How do you think these substances came to be inside the plants?

Why We Add Lime to Clay





○ – Calcium
● – Carbon
🟠 – Oxygen

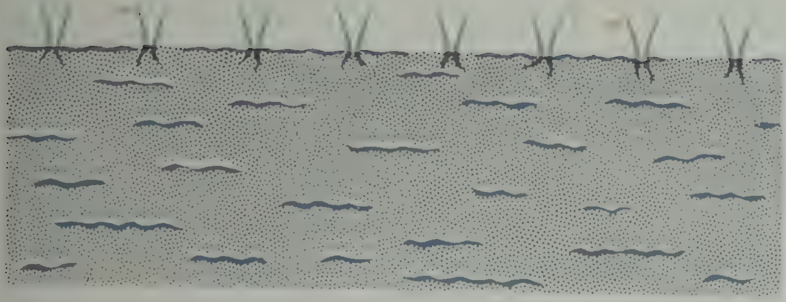
Limestone is a hard form of chalk. If it is broken down into the smallest particles possible—into what are called molecules—each particle will contain one atom of calcium, one of carbon, and three of oxygen. When limestone is strongly heated, each molecule loses one atom of carbon and two of oxygen. These atoms, combined together, form carbon dioxide gas which goes into the air. The molecules left in the furnace contain one atom of calcium and one of oxygen. Calcium and oxygen combined in this proportion make lime.

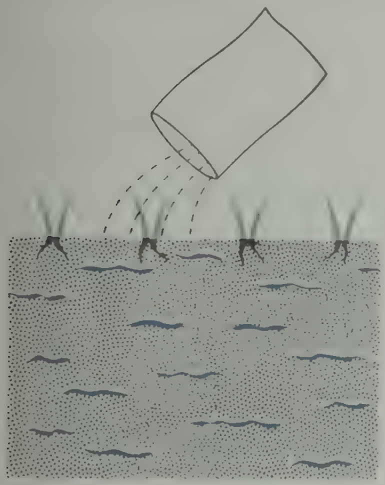
1 The pictures below the line show the chemical changes which take place in lime when it is used for making mortar. What atoms are contained in one molecule of lime?

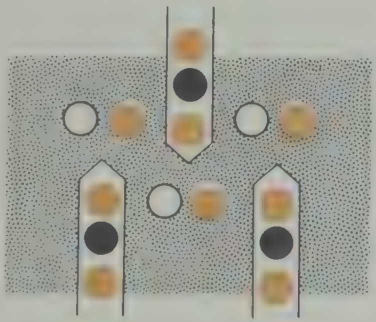
2 Name the gas which joins itself to the lime while it is wet.

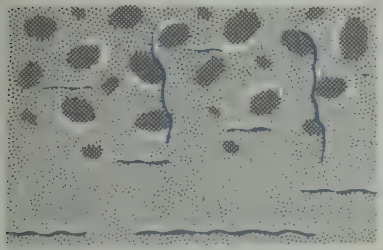
3 Name the substance which is made when lime and carbon dioxide are chemically joined together.

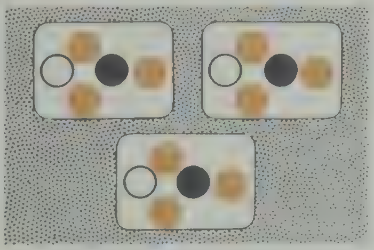
4 Explain how lime helps to make mortar set firm and hard.

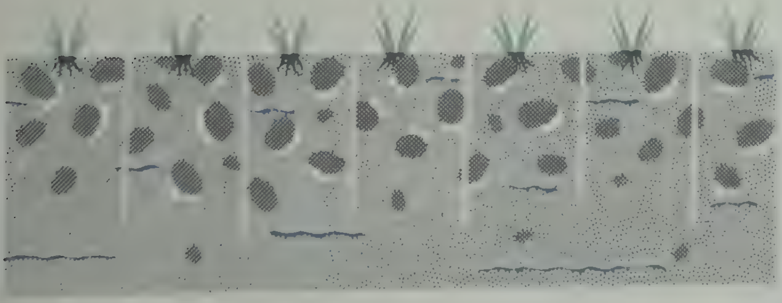












5 Is the weak grass growing in clay soil or in sandy soil?

6 Is there much air in the soil around the roots of the grass? Do the roots need oxygen?

7 When lime is sprinkled on the wet soil, what gas begins to mix with it? Does all this gas come from the air?

8 Look again at the pictures on page 18, then try to explain how carbon dioxide entered the soil.

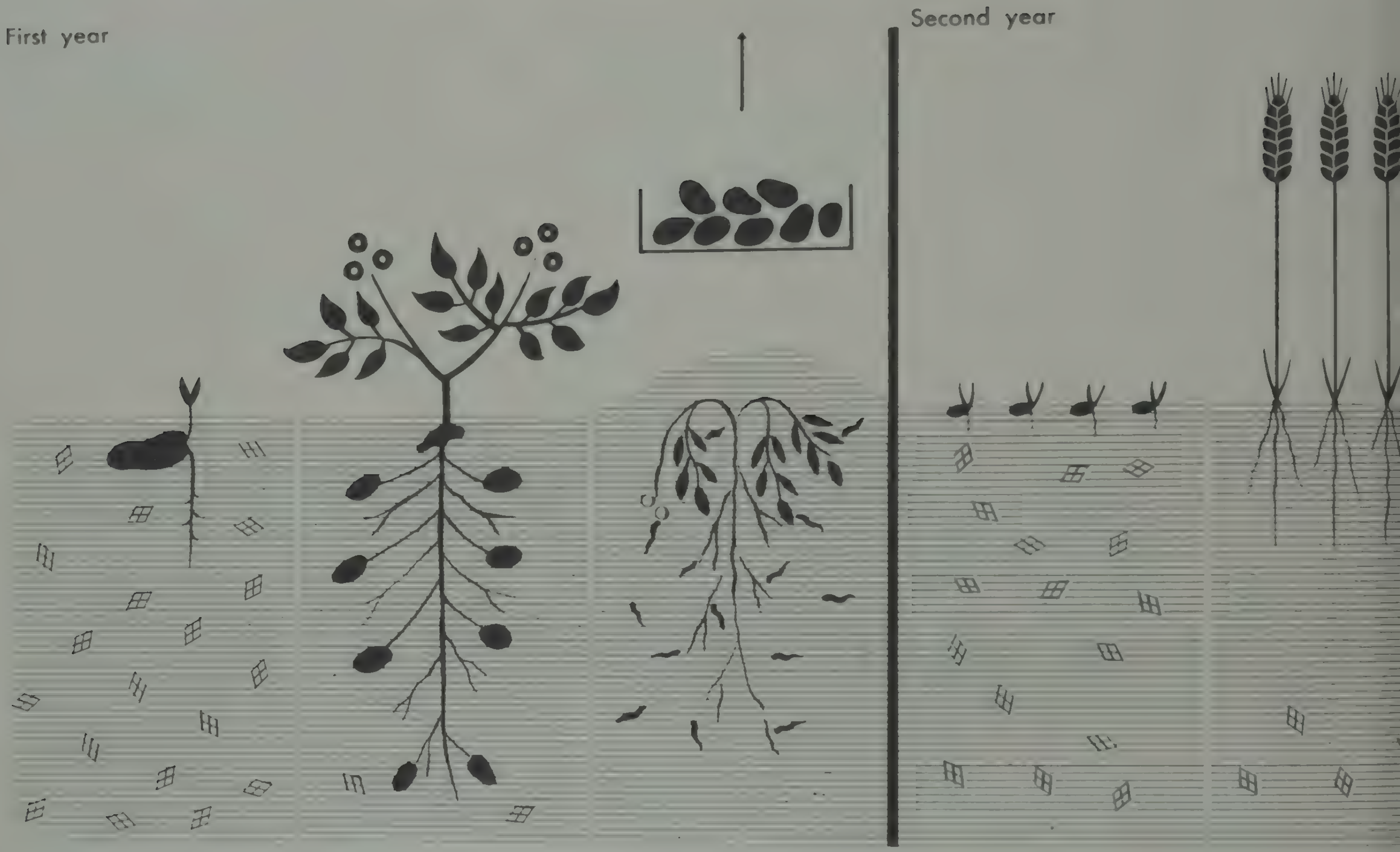
9 Name the substance which is formed when carbon dioxide combines with lime.

10 What changes take place in the soil particles when the lime has combined with carbon dioxide? Does the soil become lighter or heavier? More moist or less?

11 Look at the bottom picture. Is there more or less air between the soil particles than there was in the top picture? How does this help to make the grass grow better?

12 Look at the top picture on page 10. Did the oak trees and wild flowers grow in pure clay?

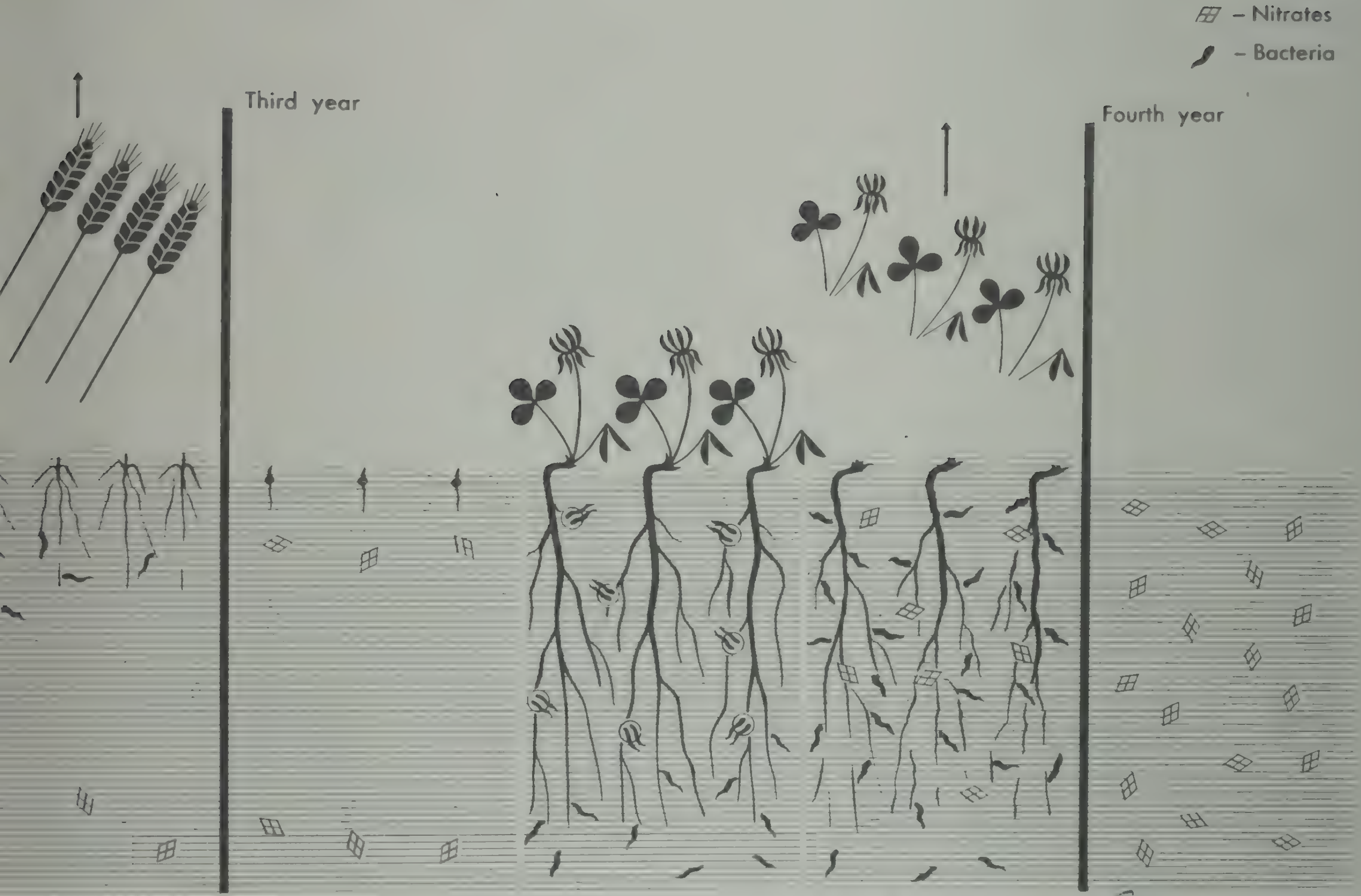
Changing the Crops to Enrich the Soil



We saw on page 19 that the food a plant needs is made inside its leaves: carbohydrates from carbon dioxide and water, proteins from carbon dioxide, water and *nitrogen.* But plants cannot use nitrogen from the air to help make protein; instead, they must take it from the soil.

In good, rich soil there are salts called nitrates which contain nitrogen. These salts dissolve in water and enter the roots of plants. The pictures on these pages show how a farmer, by growing different crops on his land each year, can help nature to replace the nitrates which plants take from the soil.

In the spring of the first year the soil has a good supply of nitrates, and potatoes are planted. During summer the growing crop uses up a large part of this supply. After the potatoes are lifted, in autumn, the dead leaves and stems are ploughed back into the soil. Many tiny living creatures called bacteria feed on this dead vegetable stuff, and in doing so



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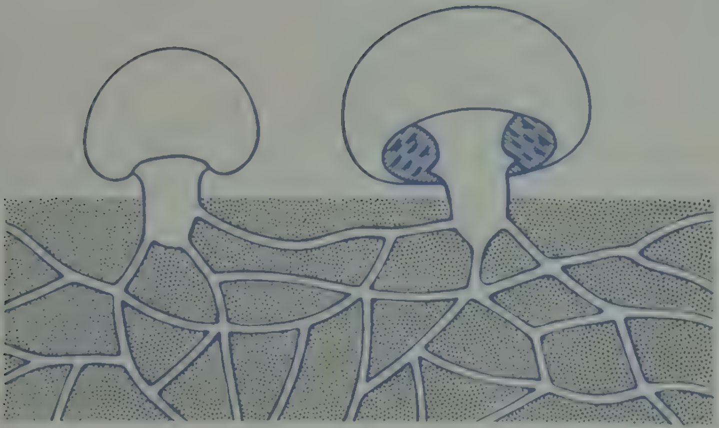
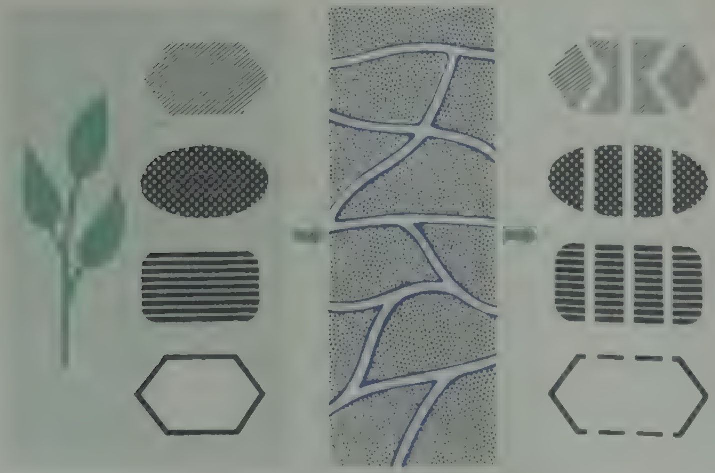
they take nitrogen from the protein part of it, and with it make nitrates.

During the spring and summer of the second year most of these new nitrates are used up by the wheat crop. When the wheat is harvested, the grain is used for flour-making and the straw for animal fodder. Only the small roots are left in the ground. Bacteria have little to feed on, and cannot make enough new nitrates to replace the amount used by the growing wheat.

In the third year the farmer sows clover. The growing clover attracts new kinds of bacteria. These enter the roots and breed so rapidly there that little swellings called "nodules" are formed. These bacteria are able to take nitrogen from the air in the soil and to combine it with other substances to form nitrates. The supply of nitrates they make is far greater than the growing clover needs. In autumn a rich supply of nitrates is left in the soil. Then the farmer can plant potatoes again.

Plants which Live on Plants





Blue stands for fungi, green for other plants and vegetable matter.

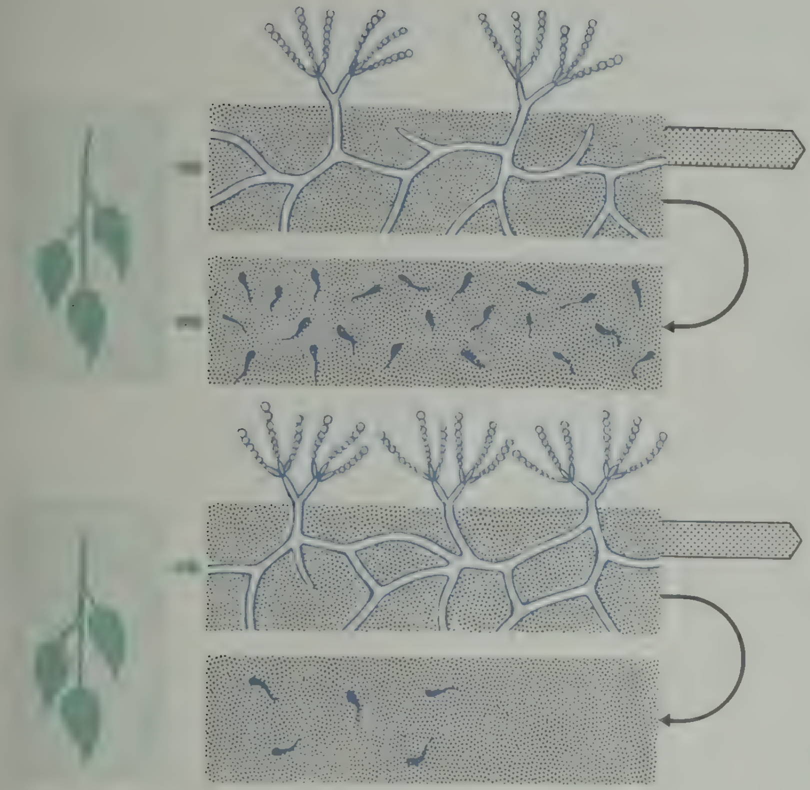
1 Fungi contain no chlorophyll. Do you think they can make carbohydrates?

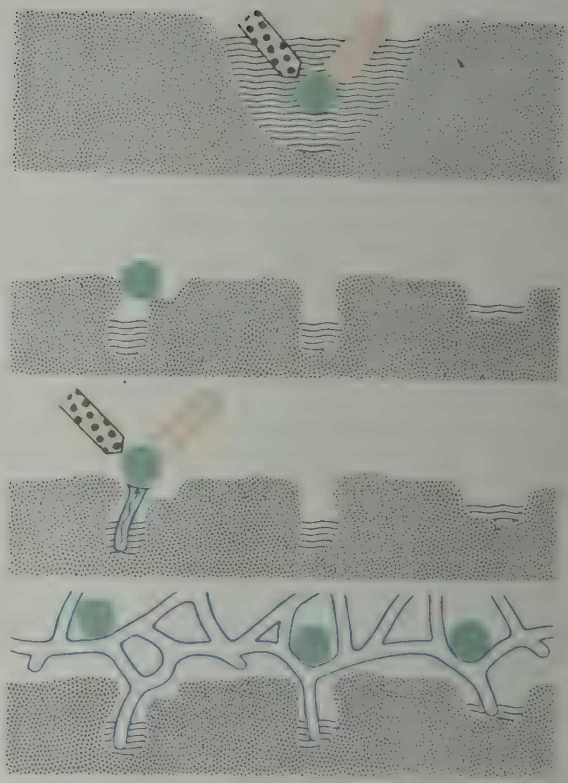
2 Name a fungus we sometimes eat. Do you think it contains protein or carbohydrate? Which part of it do we eat?

3 Name two kinds of vegetable matter in which fungi grow; two kinds of plant.

4 Do you think horse droppings contain any vegetable matter? Can fungi grow in horse droppings? Look at the picture of the growing fungus, and suggest how it draws up water and carbohydrates. What else does it draw up?

5 Are these things changed in any way inside the fungus?





We saw on pages 24 and 25 that bacteria also feed on dead vegetable matter, taking nitrogen from it and producing nitrates. Since bacteria and fungi both need the same kind of food they often live very close together, drawing their food from the same source, as you see in the pictures above. But some growing fungi produce substances which are poisonous to bacteria. These substances destroy large numbers of bacteria.

One fungus called *penicillium,* which is rather like the blue mould that grows on stale bread, produces a particularly powerful bacteria-killer called *penicillin.* Doctors use penicillin to kill the harmful bacteria which cause some of the diseases of human beings.

The tiny alga (green) contains chlorophyll. So long as it has water, carbon dioxide from the air, and sunshine, it can build up carbohydrates and feed itself. It can live in newly-formed soil which contains no other nourishment. But if the surface of the soil dries up the alga will die. The fungus has pipes which enable it to draw water up from the soil, but it cannot live unless it finds ready-made carbohydrates.

If the fungus and the alga join forces they can live together securely. The fungus takes carbohydrates from the alga, and the alga uses water which the fungus draws up for it. This combination of algæ and fungi forms lichen, the first plant to grow in new soil.

What We Have Learned about Plants and Food

All animals and human beings depend in the end on plants for their food supply. Not only do our vegetables, nuts, fruit and bread come from plants, but also our meat, eggs and butter; for there would be none of these things unless the animals which produce them had plants to live on. Most plants, on the other hand, can make their own food from substances taken from the air and the soil.

1. The leaves of plants contain a green substance called *chlorophyll*. In daylight chlorophyll can bring about chemical changes that could not take place without it.

During the day, carbon dioxide from the air enters leaves and mixes there with water. In the presence of the sun's rays and chlorophyll, the carbon from the carbon dioxide combines with the hydrogen and oxygen of the water to form carbohydrates. The oxygen left over from the carbon dioxide passes from the leaves into the air.

2. Between the woody part of a plant stem and its outside skin there is a fibre-like layer called bast containing many tubes made up of porous cells. The protein and carbohydrates made in the leaves dissolve in juices and pass through these tubes to reach other parts of the plant, where they are stored.

3. Every molecule of chalk or limestone contains one atom of calcium, one of carbon, three of oxygen. When chalk is strongly heated, each molecule loses one atom of carbon and two of oxygen, which combine together to form carbon dioxide. The atom of calcium and the atom of oxygen which remain form a molecule of lime.

When lime is wet, the water dissolves carbon dioxide from the air. This combines with the lime and forms chalk once more.

In heavy clay soil there are very few air spaces between the soil particles. Sprinkle lime on the soil and gradually it will combine with carbon dioxide to form chalk. The chalk binds the tiny clay particles into larger pieces. This allows more air to enter the soil.

4. Plants cannot make protein without nitrogen. Nitrogen enters the roots of plants in the form of nitrates dissolved in water. Every growing crop takes some nitrate from the soil and the farmer must help nature to replace the supply which has been lost.

After he has lifted a crop of potatoes, swedes, or parsnips he may plough the tops back into the soil. Bacteria feed on this vegetable matter, take nitrogen from the protein part, and combine it with other substances to form nitrates.

Clover (and also beans, peas and lupins) attracts a different kind of bacteria which enter the roots and breed rapidly there. These bacteria take nitrogen from the air, combine it with other substances and form nitrates.

5. The plants called fungi—like mushrooms, toad-stools and the tiny "mildew"

plants that grow on damp wood or on food—contain no chlorophyll. They cannot use water and carbon dioxide to produce food. Like animals, and like ourselves they must live on ready-made carbohydrates and protein.

Fungi can only grow in places where there is living or dead vegetable matter—in rich leaf-mould, in animal droppings, on the trunk of a tree and so on.

Fungi play a very important part in enriching poor, new soil. On such soil the only green plant which can grow is the minute alga. The alga contains chlorophyll, and so long as it can get water from the soil and carbon dioxide from the air it can make its own food. But it must live on the surface of the soil where sunshine and chlorophyll help it to produce the necessary chemical changes. If the surface of the soil dries up the alga dies.

When a fungus grows on the alga, the fungus can draw up the water the alga needs, and the alga can make enough carbohydrate to feed both itself and the fungus. This combination of algæ and fungi is called lichen.

THINGS TO DO

1. Make a drawing to show how the food in (a) milk, (b) eggs, (c) mushrooms can be traced back to green plants.

2. Chalk and limestone are frequently found in the earth but lime hardly ever. Write a brief essay explaining the reasons for this.

3. See how many different kinds of fungi you can find growing in a wood near your home. (The best time of the year to do this is early autumn, but be very careful, because some of them are deadly poison.) Make drawings of each one and keep careful notes about its size and colourings, and where it was growing (leaf-mould, stump of tree, stem of growing tree, etc.).

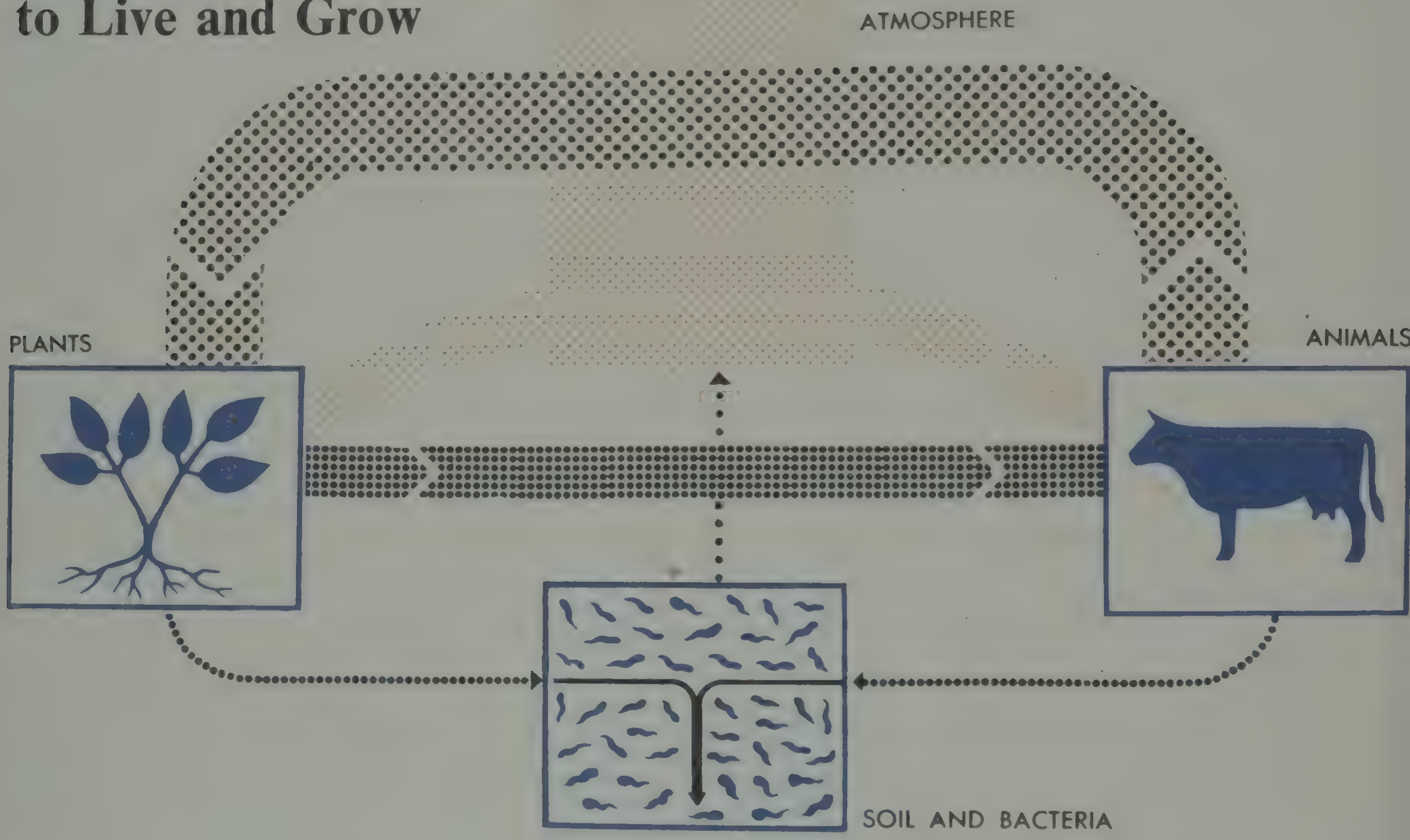
Try to identify each specimen from an encyclopaedia or nature book. Your teacher will help you to find the right books.

4. Some farmers treat their land with sodium nitrate (Chilean saltpetre) every few years. Write notes to explain (a) how sodium nitrate benefits the soil, (b) why clover need not be grown on soil treated with it.

5. Most animal droppings contain nitrogen which can be used to enrich soil. Draw a diagram to explain (a) how nitrogen came to be in these droppings, (b) how the nitrogen from the droppings can help plants to make food, and (c) how this plant-food may be used by animals.

6. Dissolve a little lime in water. (Pass the mixture through a filter paper to filter out any undissolved lime particles.) Bubble some carbon dioxide through a little lime-water and note what change takes place. Try to explain what has happened.

How Plants and Animals Help each other to Live and Grow



1 Which colour stands for carbon? Which for oxygen?

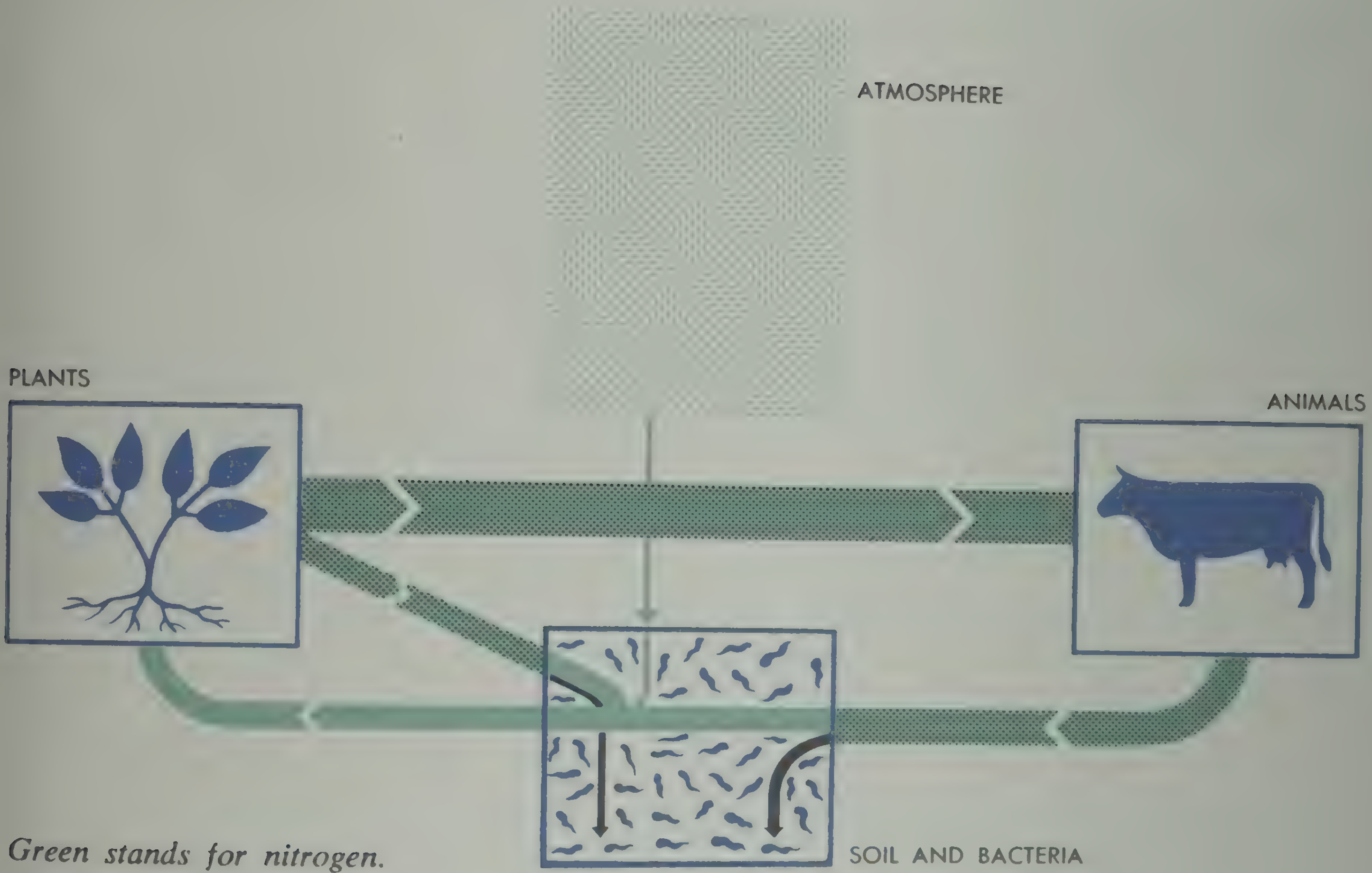
2 What gas do leaves take from the air to enable them to make carbohydrates and proteins? What gas do they give off?

3 The food which animals eat contains carbon. Where does this food come from? What gas must animals breathe in to keep them alive? How do plants supply this?

4 How do animals return carbon dioxide to the air? Can this be used again by plants?

5 Some of the carbon from plants and animals goes into the soil. Can you explain how this happens in each case?

6 How do bacteria in the soil get the oxygen they need? What gas do they breathe out? Look again at page 25 and say what effect bacteria have on dead vegetable matter.



Green stands for nitrogen.

1 What kind of food made by plants contains nitrogen?

2 Does the air contain nitrogen? Can plants get nitrogen direct from the air? Where do they get the nitrogen they need?

3 Do animals bring about any important chemical changes in the nitrogen which they breathe in and out? Where do animals get the nitrogen their bodies need?

4 How do plants help to replace the nitrogen in the soil? Do animals help to replace nitrogen taken from the soil?

5 How do bacteria help plants to use the nitrogen present in vegetable stuff in soil?

6 Can any bacteria take nitrogen from the air and make it available to plants? Can they all do so? On which page have you read about this?

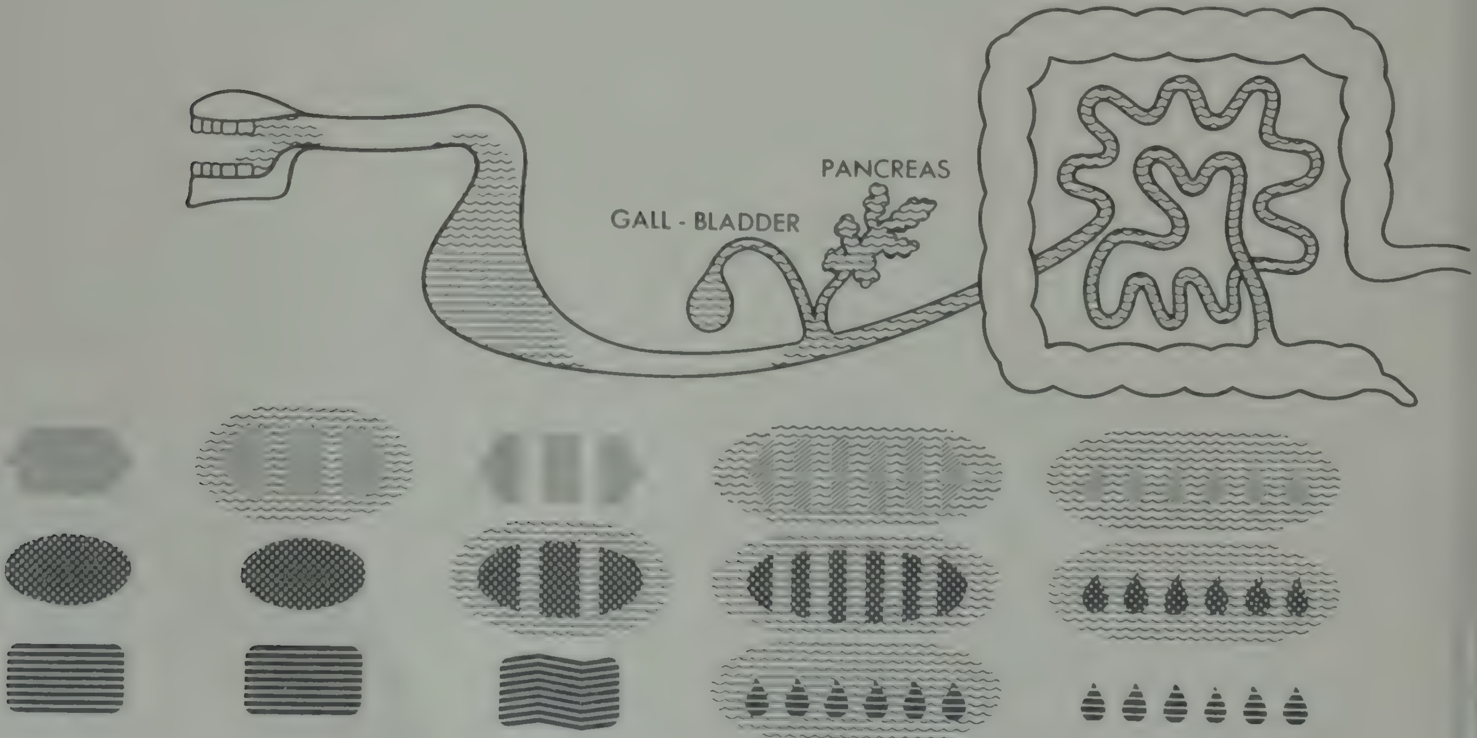
How Food Is Digested

Many parts of our body help to digest the food we eat or to prepare it for digestion. Our sharp front teeth *cut* food, our " eye " teeth *tear* it, our back teeth *grind* it into small pieces. All the time we are eating, saliva flows into our mouths softening and moistening the food so that it will pass easily through the narrow tube leading to the stomach. Saliva also begins to change the starch in flour or potato into sugars.

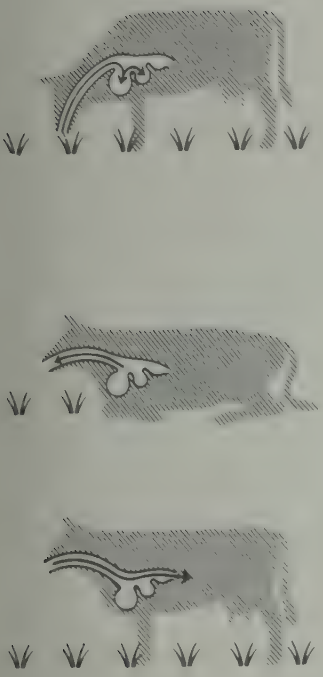
In the stomach digestive juices are released by many small glands. These juices cause chemical change in the protein. Some of the new substances produced from the protein, called *peptones* and *albumoses*, help to make still more digestive juices. The stomach also helps digestion by liquefying solid fat.

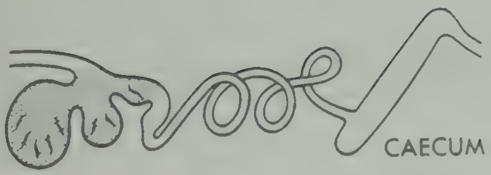
From the stomach, the partly-digested food passes into the long, winding tubes called the intestines. There *bile* from the *gall-bladder* and new kinds of digestive juices from the *pancreas* and other smaller glands mix with it and produce changes in all types of food.

These changes continue in the small intestine and there the food particles become so small that they can pass through the walls of the intestines into the blood-stream.

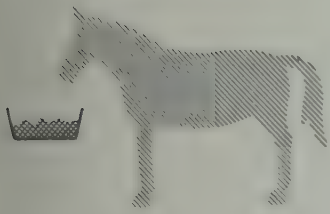


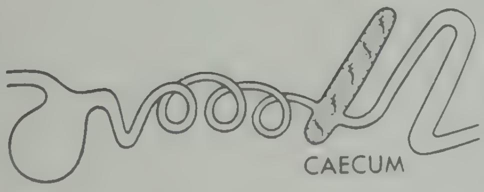
When a cow is grazing, it swallows the grass after scarcely any chewing. There are four compartments in the cow's stomach, and the coarse grass enters only the first two. When the cow has finished eating she lies down, and the grass passes, a little at a time, from the stomach back to her mouth, where she chews it for quite a long time. This is called "chewing the cud". The grass mixes with saliva and then passes through other compartments of the stomach and through the intestines to complete the digestion. In the cow's large stomach there are many bacteria which break up the hard cellulose in the grass and change it into sugar.

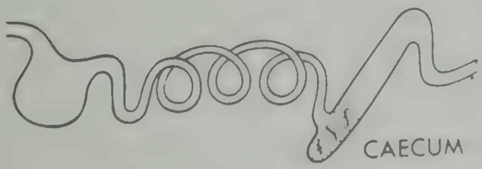


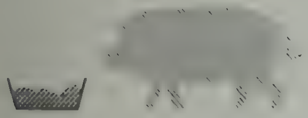


Horses and pigs do not chew the cud, like cows, but they are both able to digest cellulose. They each have bacteria in the food canal, especially in the *cæcum*, near where the narrow intestine begins to widen. In the horse the cæcum is rather large, in the pig it is rather small.

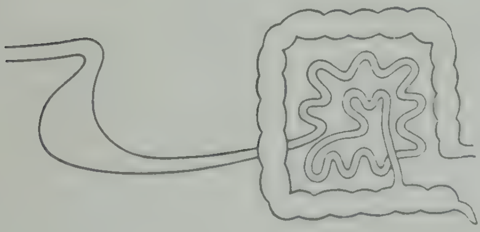




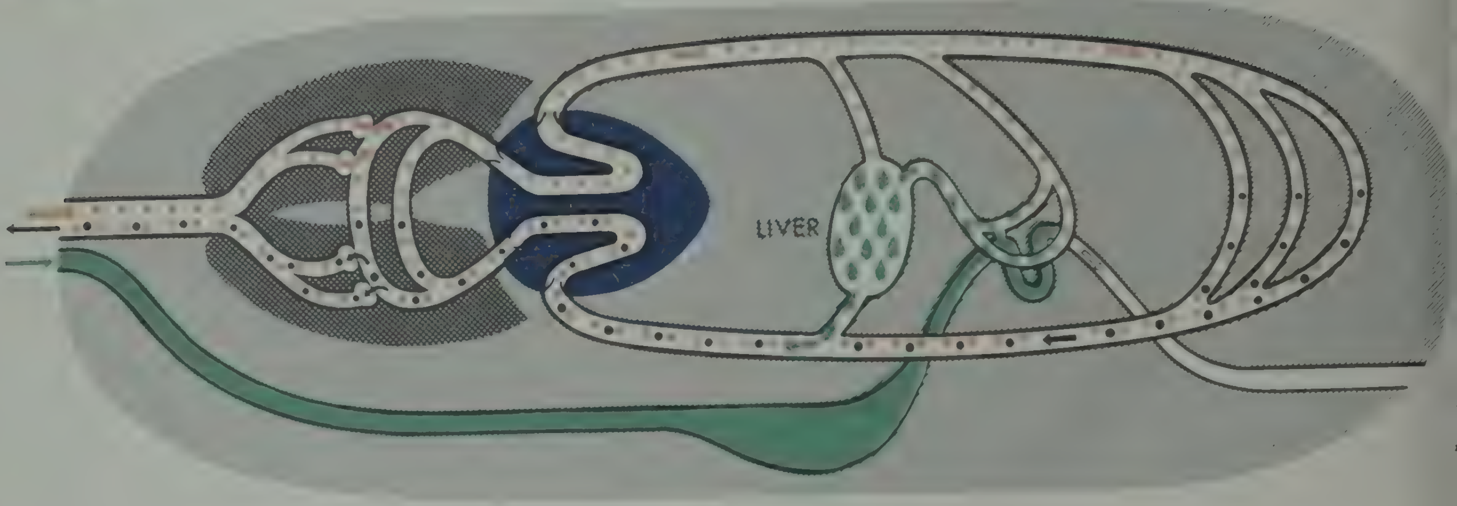




Human beings also have a cæcum, but it contains hardly any bacteria to help digest cellulose. That is why much of our food has to be cooked. Cooking breaks up cellulose so that our bodies can more easily digest food.



Food, Blood and Air



In all the pictures on these two pages green stands for food, orange stands for oxygen, black dots stand for carbon, and blue stands for the heart.

Although different animals have differently-made bodies, they all produce warmth and energy from food and oxygen, and they all expel waste food from the body. The oxygen they breathe enters the blood which is kept moving by the pumping action of the heart. Food passes through the walls of the digestive organs into the blood. The blood carries food and oxygen to cells in all parts of the body. There they combine together like fuel and oxygen combining in a fire. Energy and heat result. The waste gases which are produced are breathed out.

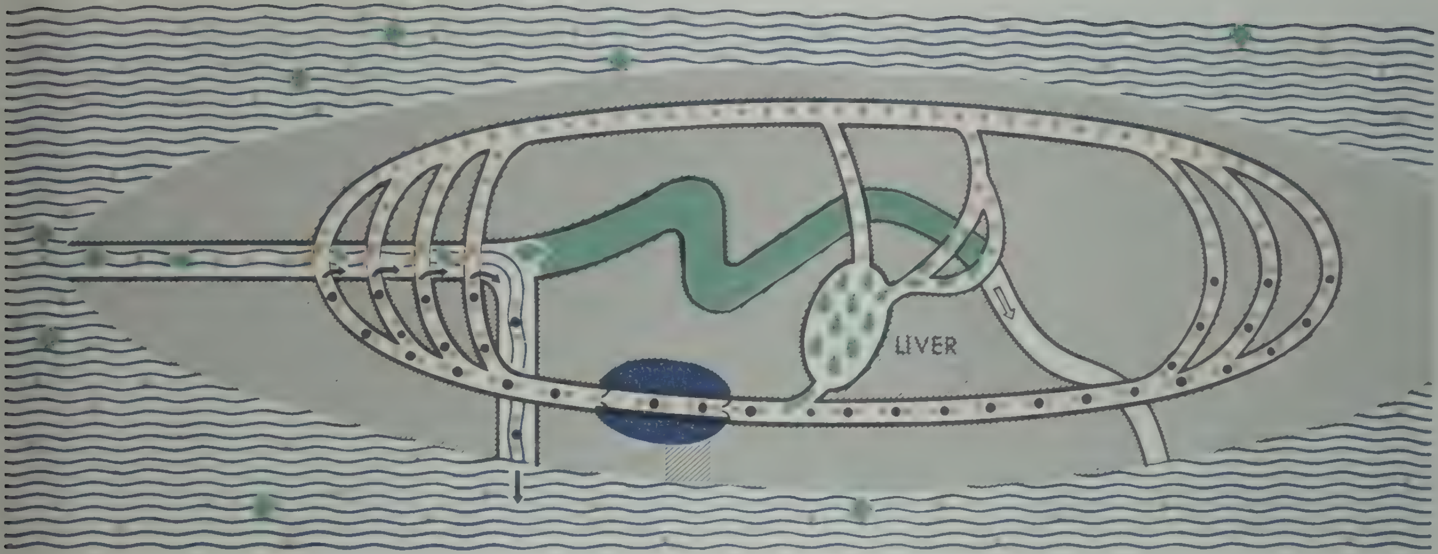
1 Some of the food the pig digests is store in the liver for quick use. Does the fis also have a liver where it can stor digested food? Does the insect?

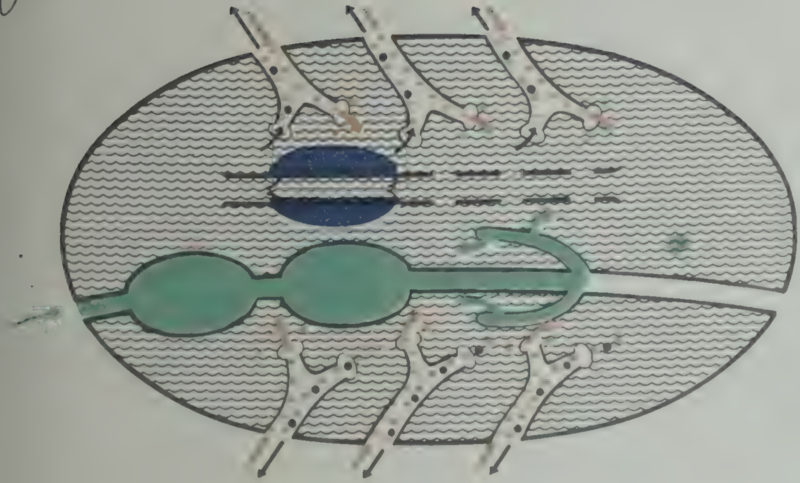
2 Which of these animals has lungs? Fro where does the fish get oxygen? Wha part do its gills play in breathing?

3 The blood vessels containing mor oxygen are called arteries. Which of th animals have arteries?

4 How does the insect take in the oxyge it needs?

5 How does it breathe out the waste gas which are formed in its body?





6 Food contains carbon. When carbon combines with oxygen in the body what gas is formed?

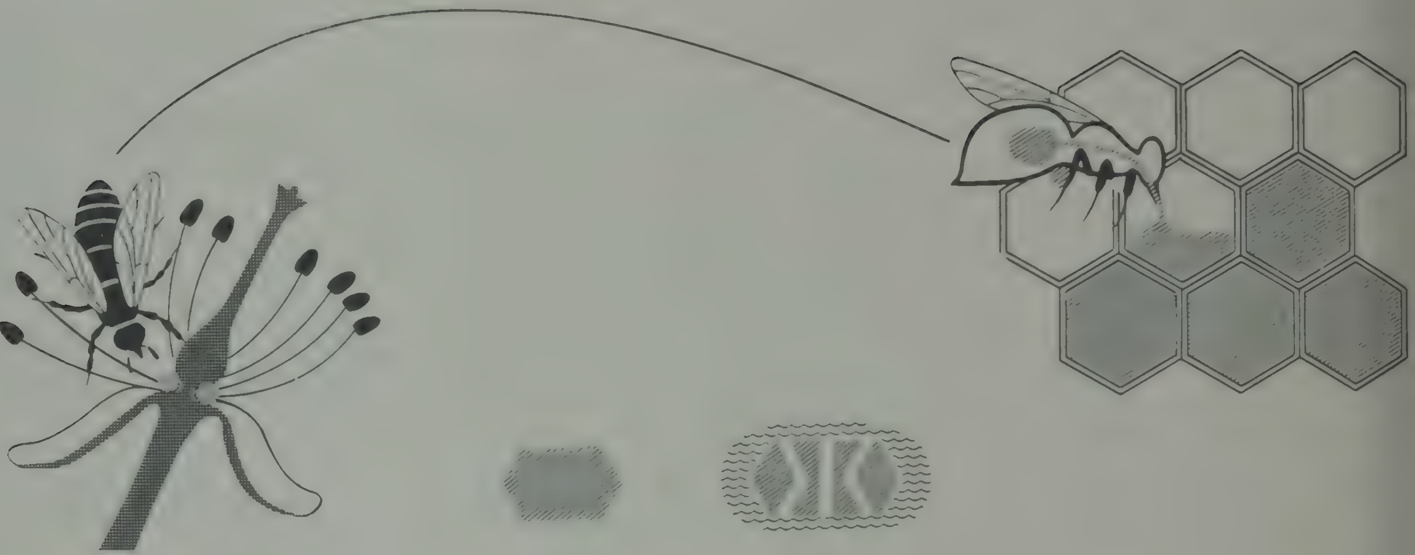
7 Does the pig breathe out carbon dioxide? Does the fish? Does the insect?

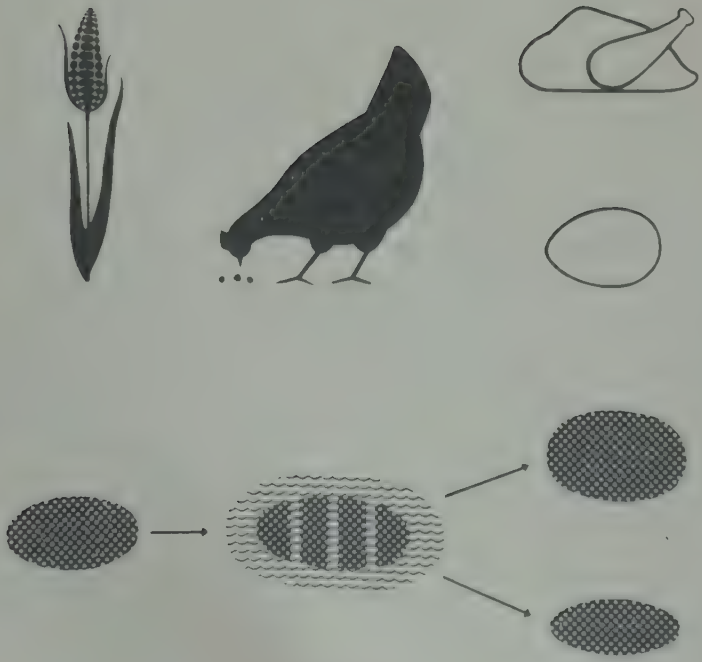
8 Do the hearts of all three have valves? Can you think what purpose these valves serve?

9 Does the pig's blood circulate through arteries and veins? Does the fish's? Does the insect's?

10 How does the insect's heart keep its blood moving?

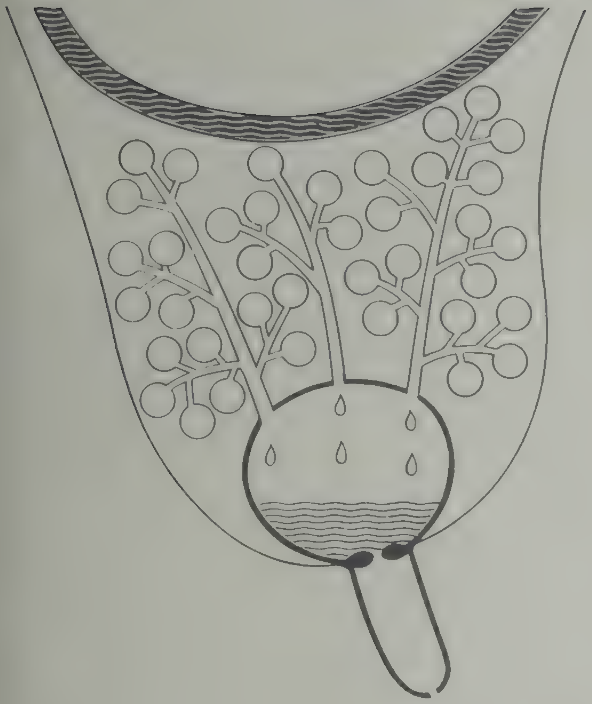
Animals Which Give Us Food

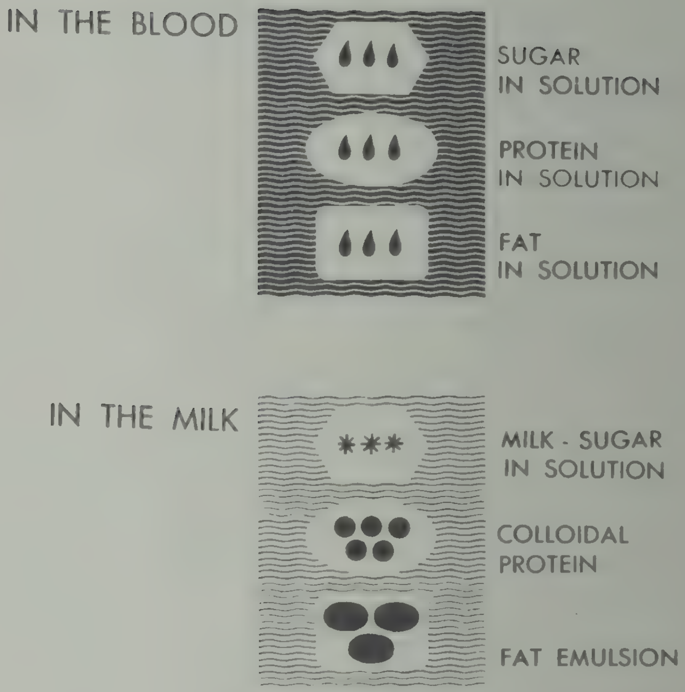




Although animals cannot *make* carbohydrates and proteins as plants do, they can change them in various ways. The nectar which bees take from flowers often contains sugar though not the same kind as that of the sugar-cane. Inside the bee, juices from glands mix with it and change it into sugars which are sweeter and easier to digest. These sugars form the main content of honey.

Maize contains a great deal of protein of a kind which the human body cannot make full use of. People whose only protein food is maize often become weak and ill. Inside the body of a hen, the maize-protein is changed into other proteins which the human body ca deal with. These valuable protein foods are stored in the flesh and in the eggs of the hen.





We saw on page 32 how the solid food we eat is gradually broken down until it dissolves and passes into the blood-stream. When we say particles are "dissolved", we mean they are mixed with liquid in so close a way that they can only be separated again by evaporating the liquid—say by boiling the mixture.

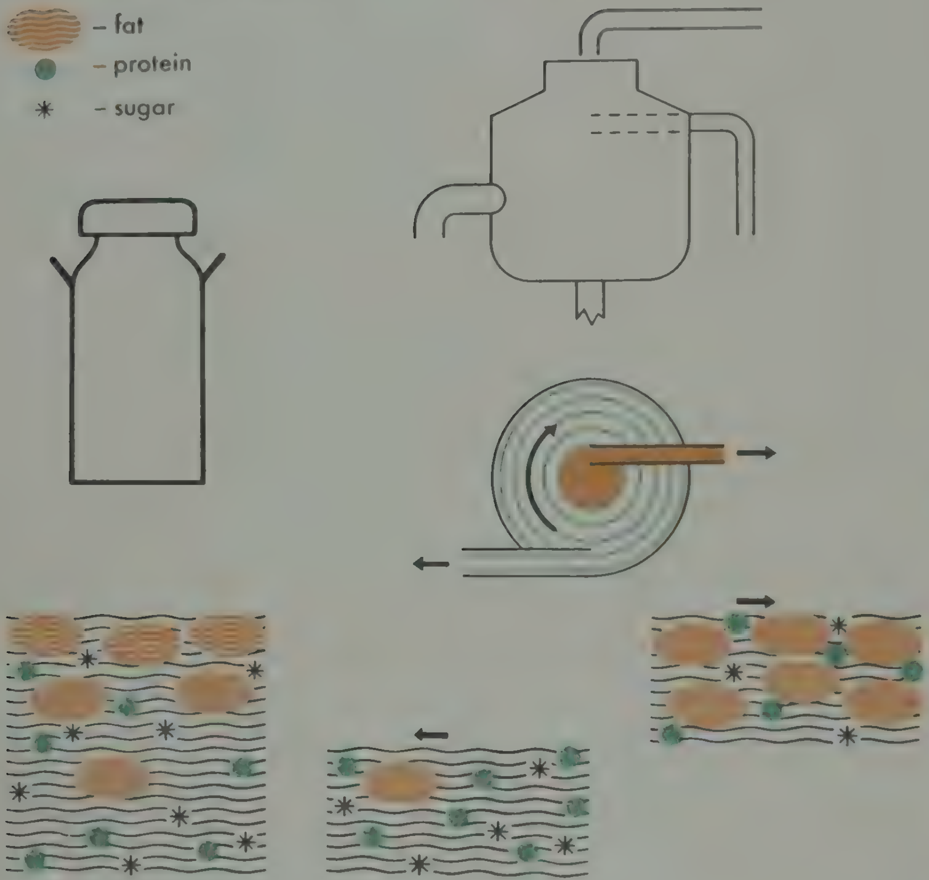
Inside the udder of a cow there are glands which change some of the food dissolved in blood and mix it with water to form milk.

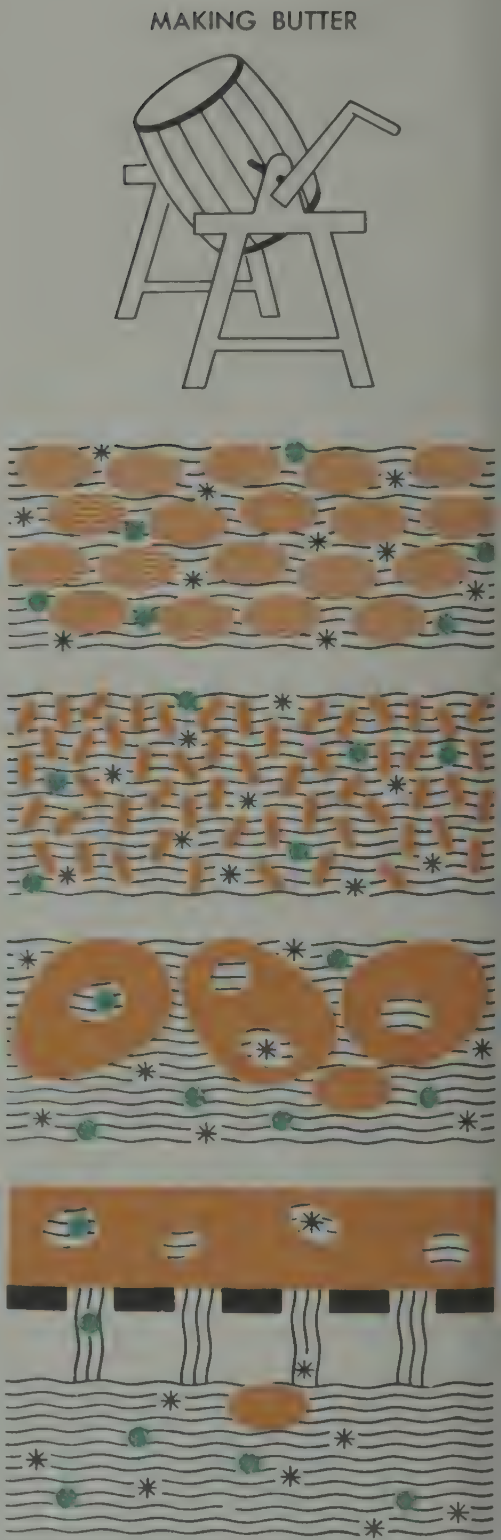
In the cow's blood *all* the food particles are dissolved. In milk only sugars and salts remain dissolved. Protein particles have become rather larger and they are mixed with water in the form of a *colloidal solution*, that is in the same kind of way that tiny particles of gelatine mix with hot water. Fats are mixed with water in the form of an *emulsion;* that is, small globules of liquid fat are suspended in the water.

Milk, then, consists of particles of three important kinds of food mixed with water in three different ways: Sugars and salts in solution; proteins in colloidal solution; fat forming an emulsion.

Milk is a valuable food not only because it contains sugar, fats and protein, but because it contains them in forms which are very easy to digest. The delicate digestive systems of very young animals, or babies, or sick people cannot digest the protein in meat or the carbohydrates in vegetables, but they can nearly always digest the small particles of protein and sugar in milk.

Milk, Cream, Butter, Cheese

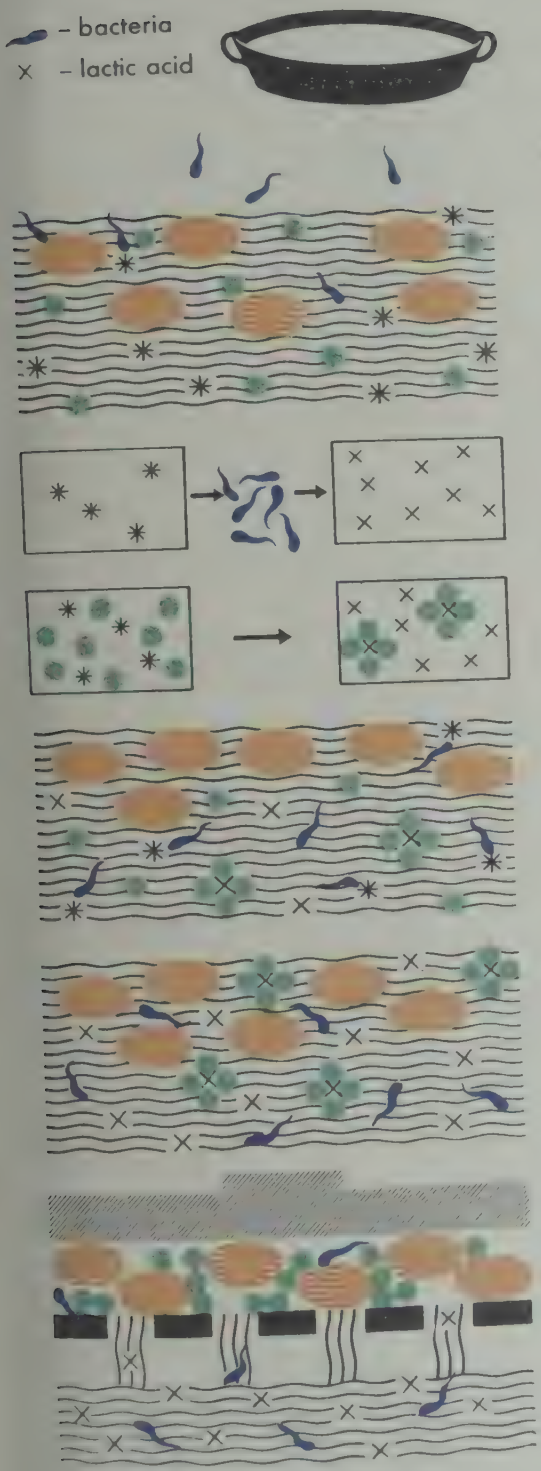




In fresh milk, proteins and sugar are evenly mixed with water, but the globules of fat have a tendency to rise towards the top because they are lighter, bulk for bulk, than water.

Dairy farmers use machines called separators, in which milk is whirled round rapidly. The whirling motion throws the heavier particles of the milk towards the outside of the machine where it passes out through a pipe. This is skimmed milk. Most of the light globules of fat, mixed with some sugar and proteins, move towards the centre, and drain off from a second pipe. They have formed cream.

MAKING CHEESE



Look at the pictures showing butter-making.

1 Look at picture one, and say whether a dairyman uses fresh milk, skimmed milk or cream for making butter.

2 The second picture shows what happens soon after churning begins. What do you notice about the bits of fat? Do they become smaller still as churning goes on (picture three)?

3 Do the large masses in picture three contain anything else besides fat? What has happened to the fat when the churning finishes (picture four)?

4 Which contains more water, the cream in the first picture or the butter in the last?

5 When the solid butter is made, liquid is strained off and remains at the bottom of the churn. Name the substances in the liquid and say how each of them is mixed with water. Do you think the liquid has any food value?

Now look at the pictures showing cheese-making.

6 When fresh milk is kept for a time bacteria from the air enter it. Look carefully at the top two small pictures and say which ingredient of the milk they change.

7 As the sugar is broken down by the bacteria, what new substance is produced? What effect does this substance have on the particles of protein?

8 When most of the milk has been turned into cheese, some liquid still remains. Name the substance which this liquid contains. Do you think it has much food value?

What We Have Learned About Animals and Food

We saw earlier that all animals and human beings depend on plants for their supply of food. But although animals cannot *make* food as plants do, they change it in a number of important ways. Some of the chemical changes which go on inside the bodies of animals help to produce warmth and energy; others help to build or replace bone and muscle tissues; still others produce new kinds of food especially suitable for very young animals.

1. Pure carbon is a black substance like powdered charcoal, but in nature it is usually found combined with other substances. Plants need carbon to help make carbohydrates and proteins, but they can only use carbon which is combined with oxygen, in the form of carbon dioxide. Animals must also have carbon to help them to produce warmth and energy, but they can only use carbon which is combined with other substances in the form of carbohydrates or proteins.

2. Another substance which both animals and plants must have is nitrogen. Pure nitrogen is an invisible gas, but it can join itself to other substances to form nitrates and proteins, which are liquids or solids. Plants draw up from the soil nitrates dissolved in water. Inside the leaves, the nitrogen from the nitrates is chemically combined with carbon, hydrogen and oxygen to form proteins, most of which can be used as animal food.

3. Digestion is the name we give to the complicated processes which break down the food animals eat into tiny particles which can pass into the blood-stream.

Digestion begins in the mouth, where our teeth break up food and where saliva softens it. The saliva also produces chemical changes in some of the carbohydrates. Besides continuing to break down carbohydrates, digestive juices in the stomach begin to change proteins, and also turn solid fat into liquid. Digestion is completed in the intestine which receives digestive juices from the gall-bladder, the pancreas, and many small glands. In the intestine the food is broken down into simpler substances and smaller particles. These small particles can pass through the walls of the intestine into the blood-stream.

4. Animals differ enormously in the size, shape and structure of their bodies, but all produce warmth and energy from food in much the same way.

When the food is digested, it passes into the blood, which also contains oxygen from the air which the animal breathes. The heart acts as a pump and keeps the blood moving so that it reaches cells in all parts of the body. In the body cells, the oxygen combines with the carbon from the digested food and produces carbon dioxide, which is breathed out.

5. Honey, eggs and milk are examples of foods which have been changed inside the

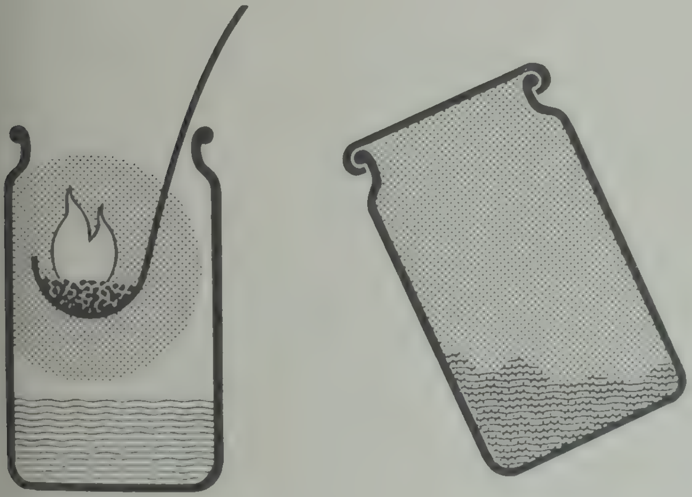
bodies of animals. Bees take a kind of sugar from the nectar of plants and change it into the sweeter, more digestible fruit sugar which we find in honey. The hen changes the protein from maize, which human beings cannot fully digest, into the easily digestible kind of protein contained in eggs.

Glands inside the udder of the cow build up some of the dissolved food particles from the blood-stream into the rather larger particles of fat and protein contained in milk. Milk contains all the main foods animals need.

6. At the dairy fresh milk is rapidly whirled round inside a separator. The rather heavy skimmed milk is thus separated from the rather light cream. Butter is made by rapidly beating an emulsion of fat in water until it changes into an emulsion of water in fat.

When bacteria feed on the sugar in milk they produce a substance called lactic acid. In the presence of lactic acid the protein particles coagulate (join together) to form a hard mass. It is in this way that cheese is made.

THINGS TO DO



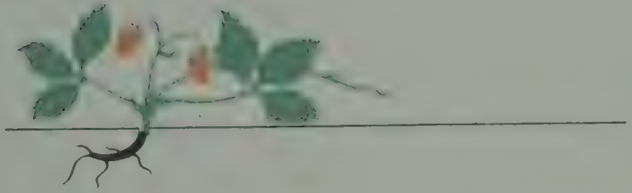
1. Place some granulated sugar in a long spoon and set light to it in a flame. While the sugar is still burning, dip the spoon into a jar containing a little lime-water, as shown in the diagram. After a few seconds withdraw the spoon, place the lid on the jar and shake well. What happens to the lime-water? What gas do you think the burning sugar produced? What substance must sugar contain in order to produce this gas when it burns?

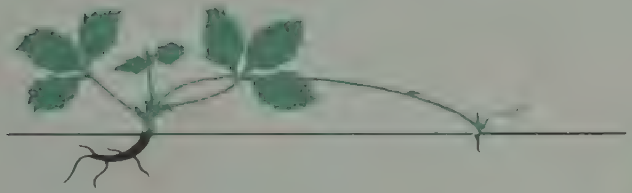
2. Repeat the experiment, using starch instead of sugar. Does the lime-water change in a similar way?

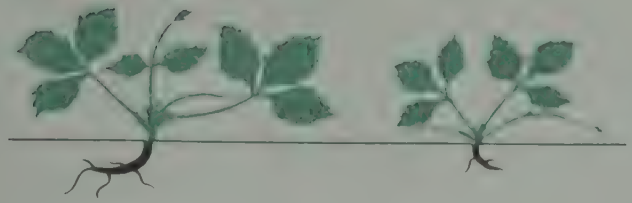
3. Leave a bottle of milk in a warm place until it turns sour and begins to curdle. Empty the milk into a clean linen or muslin bag and hang it up for twenty-four hours, leaving a basin under it to catch the drips. Turn the contents of the bag out into a dish and beat well with a little salt and pepper, and you will have made cream cheese. (Some people add caraway to improve the flavour.)

4. Explain why an unsweetened biscuit tastes sweet after you have chewed it for a time. What effect does saliva have on starch?

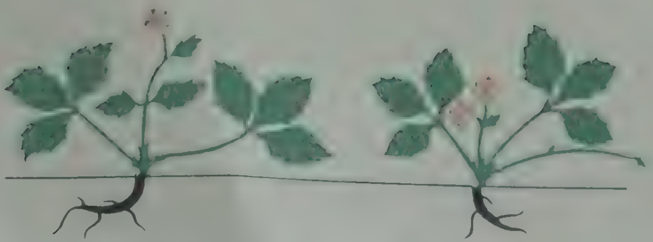
New Plants from Old

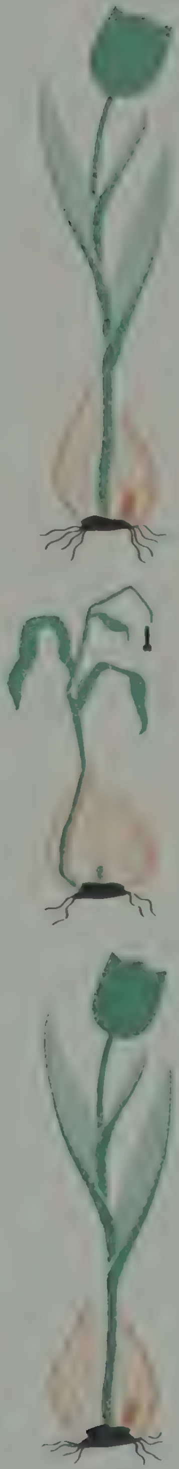






Next year





1 How many strawberry plants are shown in the first picture? What time of the year is it?

2 After the ripe strawberries have been picked does the plant still go on growing? What happens to the long runner that grows close to the ground?

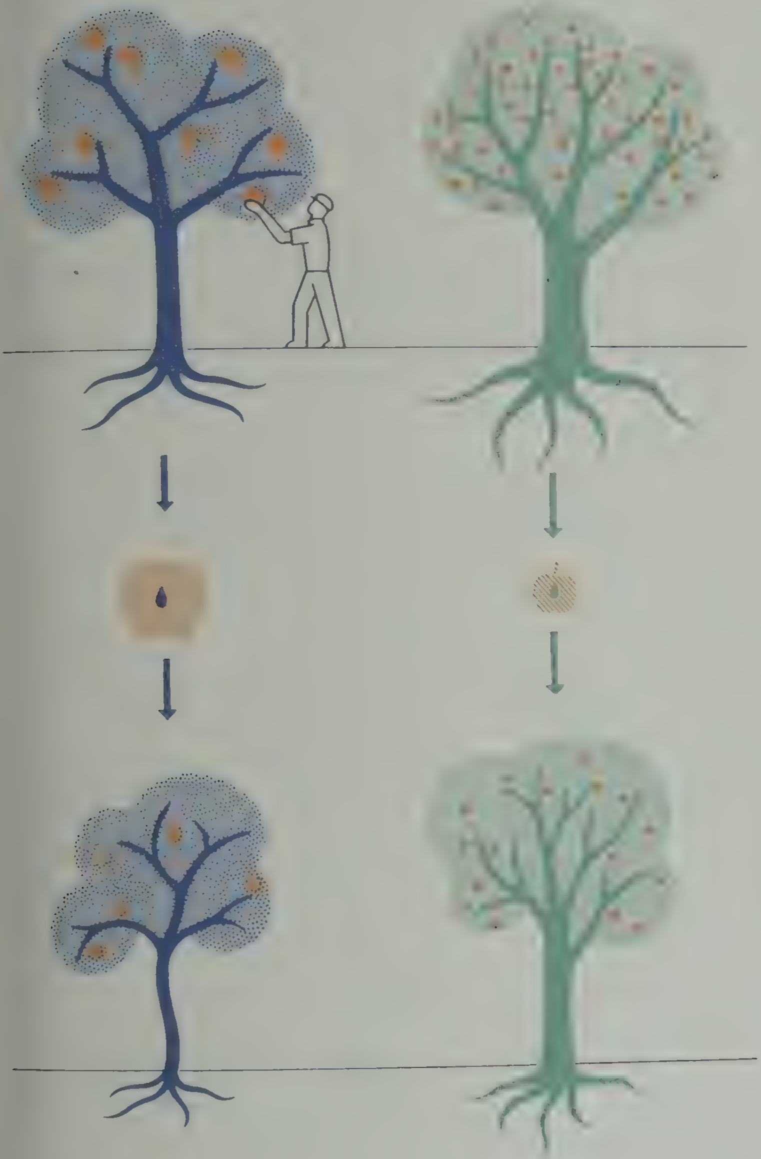
3 How many plants are there in the third picture? Explain how the new plant began to grow.

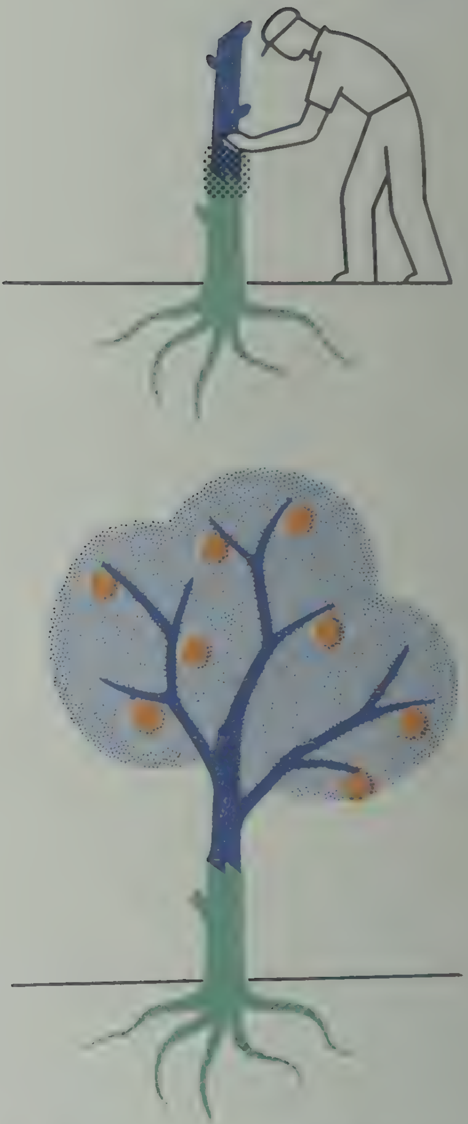
4 Do both plants have blossoms the next year? Do you think they will both bear fruit? What do you think will happen to the runner growing from the new plant?

5 Could the tulip in the top picture make its own food before its leaves grew? Where did it take its food from when it first began to grow? Why is the bulb withered?

6 In summer food is made inside the leaves. Point out the small new bulb where some of it is stored.

7 Look carefully and say what has happened to the bulb by the end of the summer. Describe what happens next spring.

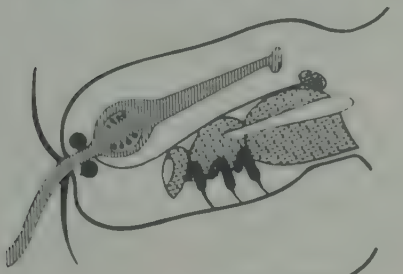




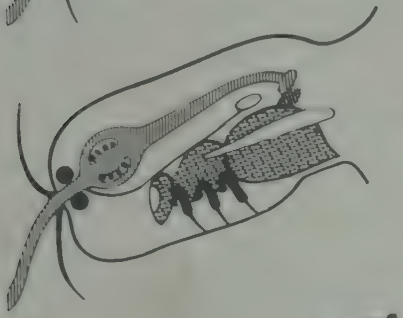
The first tree at the top bears large apples, but it has poor roots. A young tree grown from one of its seeds will probably be much the same. The second tree has strong roots but bears many small crab-apples. A young tree grown from one of *its* seeds will also probably be much the same.

How does the farmer get a tree with strong roots bearing many good apples? In autumn he cuts off the tops of the stems of both trees, making the cuts in a Z-shape. He fixes the top of the good apple-tree stem into the strong trunk of the other tree and binds up the join. The tree is stronger and bears large apples.

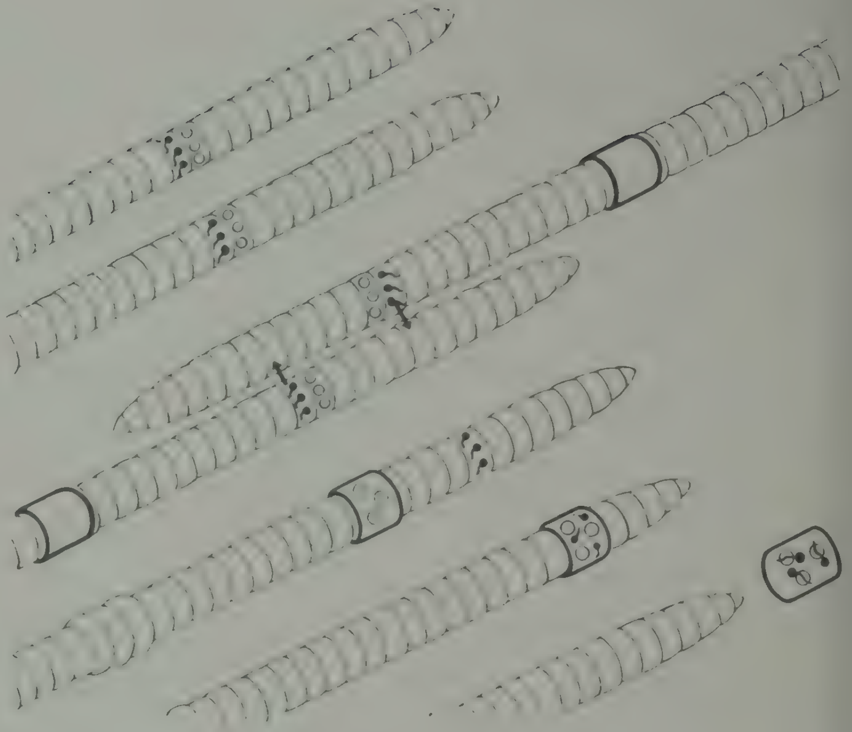
Parents and Young

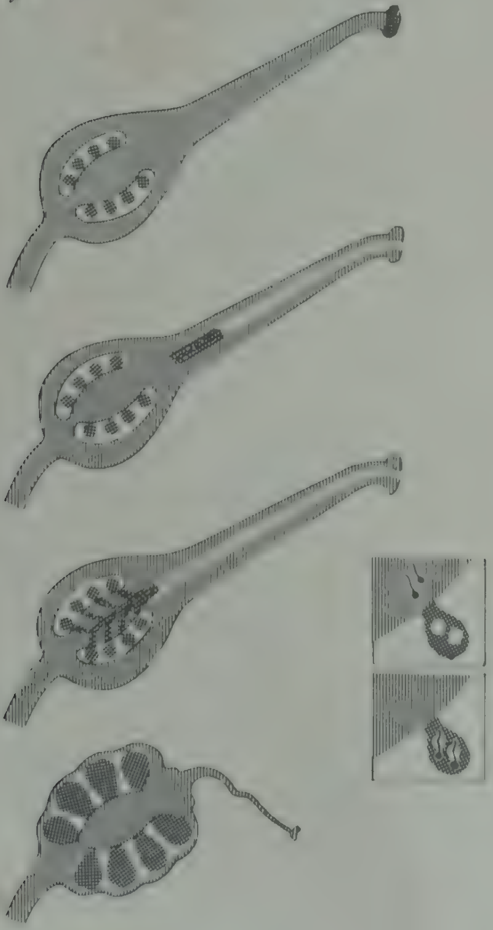


First flower



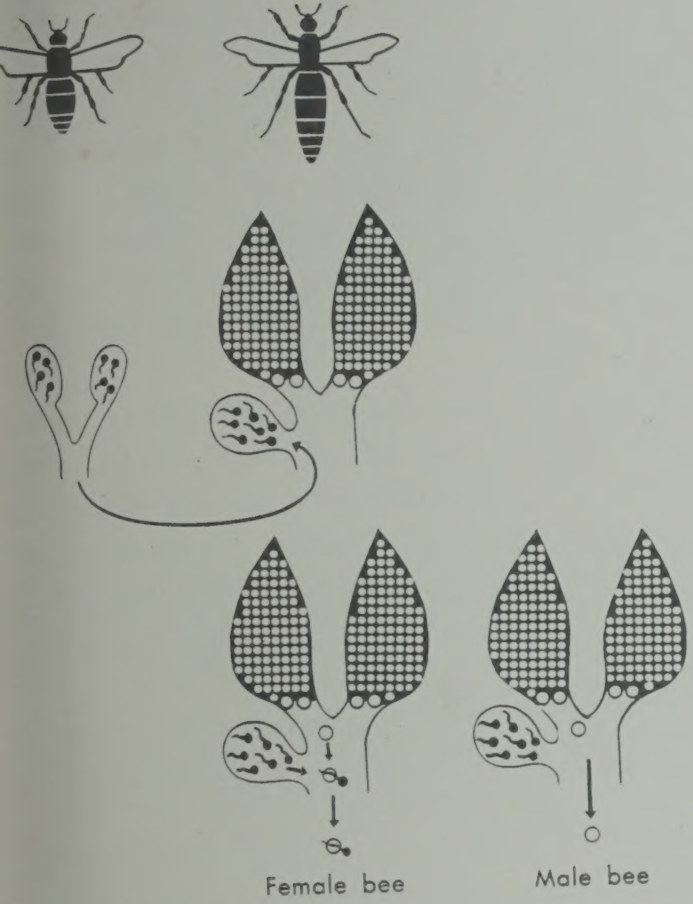
Second flower

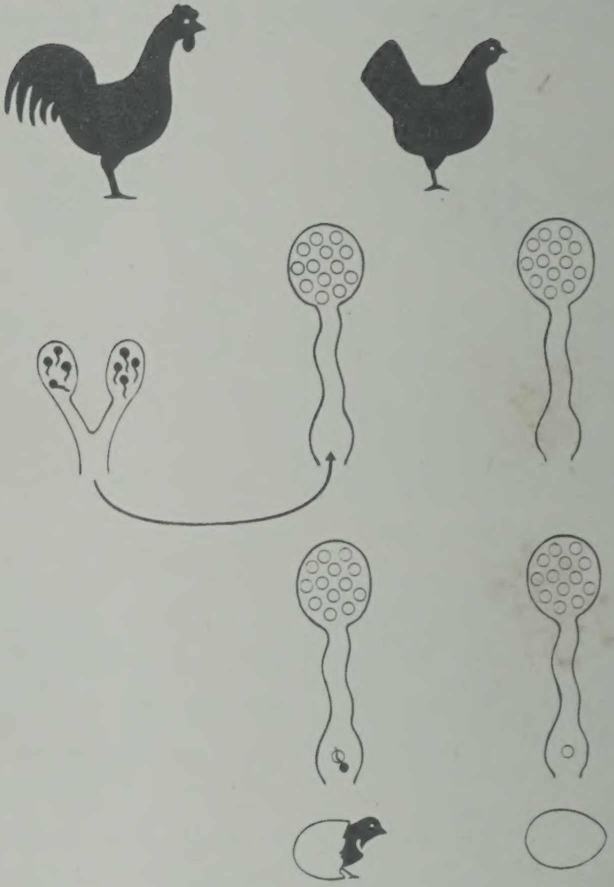




When a bee enters the first snapdragon, pollen from the stamen (the male part of the flower) sticks to its back. When it visits another snapdragon, pollen clings to the stigma (the female part) and begins to germinate. Tubes grow from the pollen grains into the ovary, or seed-vessel, of the flower. They make contact with the unripe seeds called ovules. The ovules then become ripe seeds from which flowers can grow.

In animals eggs play the same part as ovules, and *sperms* play the same part as pollen. Every earthworm has a male part containing sperms near its head, and a female part containing eggs just in front. Two worms lie together, head facing tail, and each passes sperms into a small storage sac in the body of the other. Later a band of jelly-like substance around the middle of each worm becomes loose and begins to move forward. When it reaches the female part eggs cling to it; when it passes the sac where sperms are stored, some of the sperms enter it. In time the band slips over the worm's head into the earth; there sperms fertilise the eggs.





Some bees are male and produce sperms only, some are female and produce eggs only. The eggs of the queen bee are produced in a branching tube called the ovaries. When the male sends sperms into the queen's body they are stored in a sac near the opening of the oviduct (the egg-passage leading from the ovaries). Some of the eggs which pass through the oviduct are fertilised by sperms, others not. From the fertilised eggs female bees hatch out. In the case of almost all animals no living creature can come from unfertilised eggs, but from the unfertilised eggs of bees, male bees hatch out.

A cockerel produces sperms in two organs called testes. These sperms can be introduced into the oviduct of the hen.

The hen's eggs are produced in an organ called the ovary, where they grow to about the size of the yolk of an ordinary egg. They then pass into the oviduct, where they can be fertilised *only if sperms are present*. As the eggs pass on through the oviduct they are first coated with a white, jelly-like substance and then with a hard shell.

Both fertilised and unfertilised eggs can be eaten, but chicks can hatch out only from the fertilised eggs.

What We Have Learned About Reproduction

Every living thing we see in the world around us had its beginning in some other living thing very much like itself. The hen came from an egg that was once in some other hen, the bee from an egg that was once in some other bee, the bean plant from a seed that was once in some other bean plant. The process by which new living things come from other living things is called *reproduction.*

1. Only seeds which have been fertilised can produce plants; that is, seeds from the female part of a plant which have been in contact with pollen from the male part of another plant.

Some flowers have both a male part (the stamens) and a female part (the stigma). Pollen from the anthers, which are the fertile part of the stamens, can fertilise seeds in the ovary of a flower of the same sort.

2. Every earthworm also has both a male part which produces sperms and a female part which produces eggs. But the eggs of the earthworm must be fertilised by sperms from some other earthworm.

Bees and birds, like most animals, produce *either* sperms *or* eggs, but not both.

3. The germ of life in a bean seed is protected by the strong shell of the seed. The seed also contains a store of food which the young shoot uses up before it grows leaves which enable it to make its own food. Before they are hatched, young chicks are protected not only by the shell of the egg but also by the hen which sits on the whole clutch of eggs.

Female mammals do not lay eggs. The fertilised egg remains in the mother's womb where the young animal which develops from it is kept warm and protected from danger Fully digested food reaches it from th mother's b

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THINGS TO DO

1. Fix a roll of blotting paper inside a glass jam-jar keeping it pressed firmly against the sides of the jar by means of one or two coiled, springy twigs. Arrange a few flower seeds between the blotter and the glass, and pour a little water into the jar. The water will rise in the blotting paper and the seeds will be kept moist. Observe the growth of the plants.

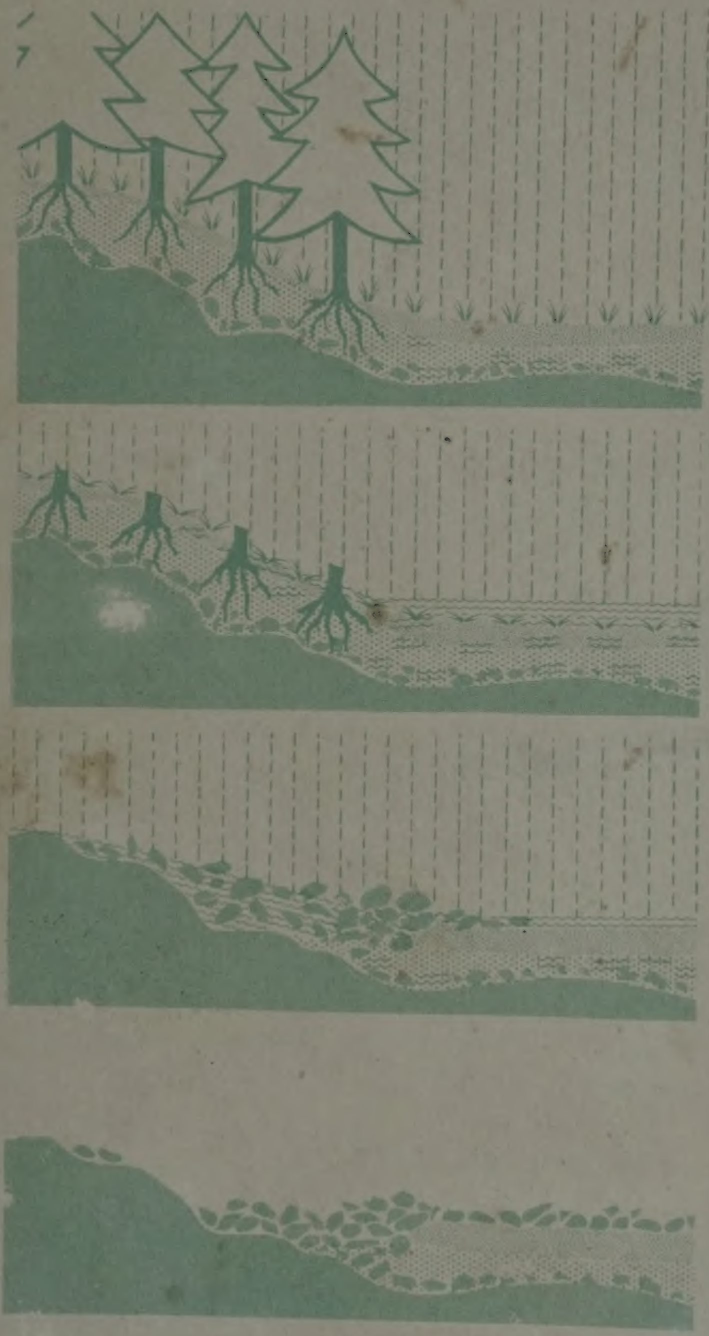
2. Observe the growth of young puppie rabbits or kittens. Keep notes showing ho old they are when they can first stand up, whe they can first move about, when they first begi to drink warm milk or water from a sauce when they first eat solid food. Note any diffe ences, apart from size, between the young ba animals and their mothers.

SOME BOOKS TO READ

As you have studied this book, you have probably felt you would like further information on some of the subjects dealt with. Below is a list of books which will help you. The easier ones are marked*, but don't be afraid to tackle some of the rather harder ones as well. They are all interesting, and many of them contain pictures which will help you to understand more about the marvels of science.

You can also add to your knowledge of living things by keeping pets, by cultivating your own patch of garden, by helping with the work of a farm whenever possible, and by paying visits to any natural history museum near your home.

Book of the Farm	*Warne*	4/6
Edible and Poisonous Fungi (Ministry of Agriculture)	*H.M. Stationery Office*	5/-
Pictorial Gardening	*Newnes & Pearson*	15/-
*AISTROP, J. B. Every Child's Book of Pets	*Dobson*	8/6
ALEXANDER, I. The Story of Plant Life	*Penguin*	1/6
*BIBBY, C. How Life is Handed On	*Nelson*	3/-
BRACHER, R. A Book of Common Flowers	*Oxford University Press*	3/-
CHAPMAN, D. H. The Seasons and the Woodman	*Cambridge University Press*	6/-
CHESSER, E. Grow Up—and Live	*Penguin*	1/6
CULLIS, W. Your Body and the Way it Works	*Allen & Unwin*	2/9
*FINDLATER, H. M. Hidden Treasure	*Pitman*	5/-
HOLT, J. M. Cooking and Nutrition	*Bell*	4/6
JOHNSON, E. How to Start Poultry Keeping	*Nelson*	1/6
*LAURENCE, W. J. C. The Young Gardener	*Allen & Unwin*	6/-
LAUWERYS, J. A. and ELLISON, J. Chemistry (with some Geology)	*University of London Press*	6/6
*LITTLE, W. B. Science in the Country	*Pitman*	5/-
*LITTLE, W. B. Science and Living Things	*Pitman*	5/-
MACKINTOSH, J. Cows and Milk	*Evans*	1/6
McWILLIAM, A. S. Soil Fertility	*Evans*	1/6
MARTINEAU, G. and EASTICK, F. C. Sugar	*Pitman*	8/6
MORSE, R. The Open Book of Wild Life	*Black*	10/6
*PRICE, H. The Junior Gardener	*Dent*	7/6
*ROWLAND, T. J. S. Living Things for Lively Youngsters	*Cassell*	7/6
*ROWLAND, T. J. S. Burning and Breathing	*Cassell*	3/6
SANDERS, E. A Book of Common Insects	*Oxford University Press*	3/-
*THORNHILL, P. The Air We Breathe	*Pilot Press*	2/6
VESEY-FITZGERALD, B. A Child's Biology	*Cassell*	8/6
*WESTWELL, W. P. and TURNER, H. E. The Pond I Know	*Dent*	2/6
*WHYTE, A. G. How Life Goes On	*Watts*	2/-



A GRADED COURSE IN GENERAL SCIENCE

School Science Review said of the first two books in the *Visual Science* series: "These are low-priced books which may well begin a new era in primary education . . . They are presented with enthusiasm, accuracy and beauty . . . They should bear fine fruit in the shape of a more scientifically educated nation." The next four books, which offer a basic course in General Science during the years from 11 to 15, are of particular value to Secondary Modern Schools and as a background course to frame the more specialised studies of the Grammar School and the Junior Technical School.

They make a radically new approach to the problem of science teaching in its early stages. Each deals with many topics stemming from one general theme, and illustrates them by reference to everyday phenomena. The emphasis throughout is on knowledge which will be of direct practical use in later life. At the same time, exercise is given in simple scientific reasoning, all the main branches of organised science are represented, and the principles of elementary science clearly emerge. Activities are focused by encouraging observation and fostering a taste for experiment.

Visual Science reflects the most progressive tendenc in science teaching. The contents rest firmly o suggestions contained in recent reports o teaching of science prepared by the Science Ma Association, the Association of Women Scie Teachers, and the Ministry of Education.